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FARMING SYSTEMS FOR SMALL FARMERS
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AN ANALYSIS OF MAIZE-COTTON FARMING SYSTEM FOR SMALL FARMERS IN GEITA DISTRICT OF TANZANIA

By

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ABSTRACT

AN ANALYSIS OF MAIZE-COTTON
FARMING SYSTEM FOR SMALL
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By

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The problems of increasing agricultural output and productivity in Tanzania vary from area to area. Some areas are faced with land scarcity. In such areas more must be produced per hectare, and land-saving technologies must be employed. Other areas face drought conditions. Thus, drought resistant crops must be given top priority.

In areas where food crops compete for resources with annual export crops, government policies may misguide farmers to allocate their resources inefficiently. This is because the obejctives of the farmer and the government are not the same. The farmer wants to utilize his resources efficiently in order to maximize net farm income after meeting family food consumption requirements. The government is concerned with increased agricultural output that farmers can sell through the controlled market.

The purpose of this study is to narrow the gap between the two by analyzing the impact of the government's measures to increase agricultural output on resource allocation, cropping patterns, and output. The study was done in Geita district, Mwanza region, Tanzania. Specifically, the objectives of the study were to:

1. evaluate the impact of the constraints imposed by farm resources on the production of cotton and maize;

2. assess the implications of oxen and tractor technological choices with respect to their impact on net return per hectare, on employment, and on labor productivity;

3. analyze the impact of rescheduling agricultural production on resource allocation, agricultural output, and farm earnings; and

4. test the sensitivity of alternative input and output prices on resource allocation, enterprise combinations and net farm income.

The data used in the study was collected from the farmers through questionnaires. The methods of analysis included static and parametric linear programming analysis.

The results of the analysis indicated that under optimum allocation of existing resources, net farm income could be increased substantially. However, further increases in farm income were hindered by seasonal labor bottlenecks.

The net farm income was influenced by product and input prices. The results showed that the official price of maize is significantly below the free-market price so that farmers sell outside official markets. Further, if input subsidies are removed, the improved farming practices experience larger declines in gross margins than the unimproved practices. This suggests the important role played by input subsidies in the system.

Depending on the realism of the assumptions made in the analysis, the results obtained from the study could provide relevant insights and guidelines for policy makers and researchers.

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Any errors or omissions found in this manuscript are solely the responsibility of the author.

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CHAPTER I

INTRODUCTION

Slightly over 90 percent of Tanzania's population lives in the rural sector and is primarily engaged in agricultural production. Most farms are small and are owned and operated by families. These farmers market approximately 40 percent of their food crops and almost 100 percent of their other crops such as cotton, tea, and coffee. They purchase about 10 percent of their labor inputs. Modern inputs, such as fertilizers, improved seeds, insecticides, and machinery, are used only minimally (Carr, 1976).

The small farms contribute over 40 percent of the Gross Domestic Product (GDP) and 80 percent of the total export earnings (Malecela, 1980). It is the agriculural sector that, to a large measure, determines the pace of economic and social development of Tanzania.[1] This sector is expected to supply the country's population with its nutrient requirements, to earn foreign exchange, which is badly needed for the development of this sector and other sectors of the economy, to provide raw materials for domestic industries, to provide a large and effective market for domestic industrial goods, and to supply labor to other sectors of the economy. The role of agriculture in the Tanzanian economy was summarized by President Nyerere (1968):

> The mistake we are making is to think that development begins with industries. It is a mistake because we do not have the means to establish many modern industries in our country. Agricultural progress is the basis of Tanzania's development. A great part of Tanzania's land is fertile and gets sufficient rain. Our country can produce various crops for home

[1] See Appendix A

> Consumption and for export. We can produce food crops (which can be exported if we can produce in large quantities) such as maise, rice, wheat, beans, groundnuts, etc. And we can produce such cash crops as sisal, cotton, coffee, tobacco, pyrethrum, tea, etc. And because the main aim of development is to get more food and more money for our other needs, our purpose must be to increase production of these agricultural crops. This is in fact the only road through which we can develop our country.

The Tanzanian government's preferred strategy for agricultural development is based on the socialist strategy of organizing production. In this strategy, the agricultural sector can be divided into four subsectors: (1) ujamaa (communal) farms, in which a group of individuals or families voluntarily own land, lives, and works together for the benefit of all; (2) state farms, which are owned and run by government agencies; (3) block farms, in which each family owns its own land, makes its own production decisions, but can easily and voluntarily share extension services, capital assets, and so forth; and (4) small holder household or family farms.

The focus of this study is on the last two subsectors. These are believed to bear the largest share of responsibility in Tanzania's agricultural development. Although the government's agricultural policy still emphasizes communal and state farms as the key of these subsectors, their apparent failure has recently led to a quiet recognition of the importance of block farming and independent small holder farming.

Statement of the Problem

The performance of the agricultural sector has not kept pace with the growing population of Tanzania. Between 1967 and 1978, the population increased by about 3.3 percent a year, whereas food production increased by only about 2.5 percent per year over the same period (Ellis, 1980). The government had to spend its foreign-exchange earnings in order to import food, and these food imports have increased in recent years (Table 1.1).

The production of export crops such as coffee, tabacco and cotton did not improve either. Total output declined from 611,654 metric tons in 1973-74 to 469,057 metric tons in 1978-79, a decrease of 23.3 percent.

The problems of increasing agricultural out put and productivity vary from one area of the country to another. Some areas are faced with rapid population growth that causes land scarcity. Such areas include the Kilimanjaro region, parts of the Lake Victoria basin, the Usambara highlands, parts of the Mbeya and Iringa regions, and around Mount Meru in the Arusha region. In such areas of land scarcity, more must be produced per hectare of farm land. Technologies that are land saving or are substitutes for land need to be employed. Perhaps the most important means of increasing agricultural productivity in land-scarce areas is increased use of high-quality farm inputs such as fertilizers, higher-yielding seeds, and pesticides. In addition, investments in such factors as rural feeder roads, marketing and storage facilities, agriculatural research, and extension services are necessary. Other areas such as Dodoma and Singida face drought conditions. For such areas, there needs to be research in drought-resistant crops such as sorghum, millet, cassava, and potatoes.

In areas where food crops compete for resources with annual export crops, there is the problem that government policies (especially pricing policy) may misguide farmers to allocate their resources inefficiently.

Table 1.1

IMPORTS AND EXPORTS OF MAJOR FOOD GRAINS 1965/66-1975/76

'000 M TONS

	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76
Maize											
Imports	8.8	7.9	-	-	46.9	-	92.3	78.9	183.6	317.2	42.3
Exports	-	-	0.3	51.8	-	53.4	-	-	-	-	-
Wheat & Flour											
Imports	21.6	32.1	13.6	36.7	35.7	11.6	49.5	8.2	35.8	109.6	31.2
Exports	-	-	-	-	-	-	-	-	-	-	-
Rice/Paddy											
Imports	11.4	6.5	3.8	-	-	-	-	-	23.0	63.0	20.6
Exports	-	-	-	-	-	-	4.2	10.2	-	-	-
TOTAL NET											
Imports	41.8	46.5	13.3	-	82.6	-	137.6	76.9	242.4	489.8	94.1
Exports	-	-	-	15.1	-	41.8	-	-	-	-	-

Source: Ministry of Agriculture, Unpublished paper, 1978.

Such areas include Tabora and Iringa where maize competes with tobacco, and Mwanza, where maize competes with cotton. Strategies for increasing agricultrual output and productivity in these areas should be based on a study of the impact of government policies on resource allocation. Such studies should concentrate on the impact of input-output price relationships on land and labor allocation, capital budgeting, and utilization of modern inputs such as fertilizers and insecticides. Where labor becomes a scarce resource, studies should center on labor-saving techniques, such as mechanization, or on a farming system that would change the demand for labor by utilizing different farming operations. For example, perhaps one of the competing crops could be grown a little earlier or later than the recommended time.

The government, however, has taken different measures in response to the decreasing agricultural output. Since 1974, a single pan-territorial (uniform) producer price for each crop has been fixed annually by the Economic Committee of the Cabinet. This uniform price applies to all major food crops, an increasing number of minor food crops such as cassava, domestic oil seeds, and to all export crops except coffee and sisal. Differentials in the uniform price are fixed for different quality grades where applicable, but no distinction is made with respect to location or transport costs.

In addition, the Revolutionary party (the only political party in Tanzania) directs regions to meet crop targets set by the party; the regions in turn set crop targets for each of their districts. This process continues up to the farm level. In most cases, these targets are quite arbitrary and are not accompanied by an incentive when they are met or by punishment when they are not met.

Furthermore, in 1975 the government signed an agreement with the World Bank by which funds were to be made available for improving agricultural practices in major crop-producing areas such as Geita (in the Mwanza region) where maize and cotton are the main crops or Tabora where tobacco and maize are widely grown. It was decided to introduce new management practices under a planned sequence of events. The new management practices involved the use of improved seeds, farmland manure (FYM) and pesticides in conjunction with inorganic fertilizers. This agreement did not cover every family farm primarily because the cost would have been very high.

As for the family farms not included in this project, the government required these farmers pay the same price for farm inputs such as fertilizer as that paid by participating farmers. Although there were no differences in input or output prices, nonparticipating farmers usually could not get enough fertilizers, or if they could, the fertilizers arrived too late because of the poor transportation system.

There is a wide gap between the knowledge of the small farmers and that of the government policy makers. The farmer is concerned with efficient utilization of his resources to maximize net farm income after meeting consumption requirements of the family. The policy makers are concerned with increased agricultural output that farmers can sell through the goverment-controlled market.

The purpose of this study is to narrow the gap between the objectives of family farms and policy makers, based on analysis of the impact of the government's measures to increase agricultural output on such factors as resource allocation, cropping patterns, and output of the family farms. Analyses of labor-saving techniques, new management practices, and changing price structures are also included in this study.

Objectives of the Study

The objectives of the study concern both the participants and non-participants of the Geita Cotton Project. The objectives are as follows:

1. to evaluate the impact of the constraints imposed by farm resources on the production of cotton and maize;
2. To assess the implications of oxen and tractor technological choices with respect to their impact on net return per hectare, on employment, and on labor productivity;
3. to analyze the impact of rescheduling agricultural production (by including early- and late-planted cotton) on resource allocation, agricultural output, and farm earnings; and
4. to test the sensitivity of alternative input and output prices on resource allocation, enterprise combinations and net farm income.

The Organization of the Study

In chapter 2, a background for the study is presented. It includes a discussion of the production patterns of cotton and maize in Tanzania, a review of past studies of these crops and of accounts of past experiences with agricultural mechanization in Tanzania.

The methodology and analytical techniques used in the study are discussed in Chapter 3. The analytical techniques consist of static and parametric linear programming analyses. The application of linear programming techniques in African agriculture is reviewed. The sources of various data sets are described.

In Chapter 4, there is a description of the characteristics of farming operations in the study area and methods for designating representative farms are discussed. The structure of the linear programming models used to represent the planning environment of the representative farms in the study area are presented in Chapter 5. Included are discussions of the model activities, technical coefficients, prices, and resource restrictions used in the study area. In Chapter 6, there is an analysis of optimum farm plans in terms of net farm income, cropping patterns, and resource use. The impact of varying product and input prices, capital and rescheduling cropping calendars on cropping patterns and resource use is also examined. A summary of this study, its implications for policy making, and suggestions for future research are presented in Chapter 7.

CHAPTER II

BACKGROUND TO THE STUDY

Agricultural Pricing Policy and Production Patterns of Cotton and Maize in Tanzania

In Chapter I, the general performance of Tanzania's agricultural sector from 1967 to 1978 was briefly discussed. In Chapter II, a discussion in greater detail is presented concerning government pricing policy and production patterns of cotton and maize, the two crops upon which this study is focused. Included in the discussion are past production trends and problems, and brief review of relevant literature pertaining to these crops.

Agricultural Pricing Policy in Tanzania

The stated objectives of Tanzanian development strategy, as contained in the Arusha Declaration, are three in number. The first objective is to achieve domestic food self-sufficiency. The second is to expand the foreign exchange earning role of the agricultural sector in order to increase the importation of capital and intermediate goods for the growth of the industrial sector. The last objective is to improve the standard of living of the rural population through increasing rural incomes. These objectives are by no means compatible. There is the problem of reconciling domestic food self-sufficiency with the foreign exchange earning role of the agricultural sector. What is consumed cannot be exported and vise-versa. There is also the problem of reconciling the objective of increasing rural incomes with the tendency for farmers to receive a progressively smaller proportion of the market value of their crop sales (Ellis).

The main characteristic feature of the marketing system in Tanzania is the high degree of centralized control dating back to 1967. The principal feature is the movement toward greater stability and uniformity of output prices for each individual crop across the country, coupled with the incorporation of an increasing number of crops into official marketing channels. Most of the important agricultural commodities are under the control of crop authorities and other statutory authorities. The Tanzania Cotton Authority (TCA) and the National Milling Corporation (NMC) are the regulatory authorities for cotton and maize respectively.

The Tanzanian government fixes the prices of food and export crops just as it does for inputs like fertilizer and insecticides, and consumer goods. These prices hold for all parts of the country. There is no distinction made with respect to location or transport cost. Differentials in the uniform price are fixed for different quality grades for many crops including coffee, cotton and tobacco.

Administered prices are often not in harmony with the stated development objectives of the government. Relative prices influence the competitive positions of crop enterprises and, therefore, determine the output mix. There is evidence that the government's control over the marketing system is one of the main causes that stagnated the agricultural sector (Ellis, International Labor Organization, and World Bank). It has been argued that the practice of fixing input and output prices restricts economic forces and hampers the efficiency allocation of resources.

Production Patterns of Cotton

The importance of cotton in the Tanzanian economy is summarized in Table 2.1. Cotton accounts for more than 17 percent of the country's total exports which in turn make up for about 30 percent of the country's GDP. The crop is an important source of foreign exchange that is badly needed to pay for imports. Because the government increasingly emphasizes rapid economic development as the long-term objective, means of acquiring the foreign exchange to pay to import capital and intermediate goods must occupy an increasingly important position. Consequently, cotton exports have an even more important role in the economy.

In addition, during the last decade, Tanzania expanded her textile industry and the production of cooking oil for the domestic market. This expansion increased the country's demand for cotton lint and cotton seed. As shown in Table 2.2, the domestic demand for cotton lint increased by about 20 percent between 1973-74 and 1979-80. Among the oilseed crops, cotton seed is ranked second to groundnuts (see Table 2.3). Cotton seed is used in the manufacture of cooking oil, margarine, and soap. Cotton seed cake, which is a valuable residue of crushing the seed, has a high protein content and is a valuable livestock feed. Any future increase in the production of cooking oil, margarine, soap, and animal feed may require a substantial increase in the production of oilseeds of which cotton seed is very important.

Over 90 percent of Tanzania's cotton is produced in the western cotton-growing area (WCGA), which is composed of the regions of Mwanza, Shinyanga, Mara, Tabora, Kagera, Kigoma, and Singida (see Figure 2.1). Shapiro, using data from the then Ministry of Agriculture, Food, and

Table 2.1

Production and Exports of the Main Export Crops

CROP		1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
COFFEE	Production[a]	51,545	46,140	49,169	45,834	51,595	54,795	50,283	53,359	48,682	43,074	49,228
	Export	48,383	48,717	44,140	34,919	53,856	59,313	40,382	53,312	56,970	46,065	50,076
	Value[b]	265.1	255.1	312.2	227.4	383.0	495.3	375.1	483.0	1,282.7	1,857.2	1,302.1
SISAL	Production	209,303	202,000	181,458	157,026	155,407	143,615	128,239	118,413	105,018	89,962	105,140
	Export	169,227	217,236	160,813	154,917	112,601	93,594	101,866	90,294	67,325	78,729	76,932
	Value	158.7	159.6	178.8	133.8	144.8	221.6	483.0	302.0	239.0	228.2	221.3
COTTON	Production	285,472	289,134	421,332	360,116	428,033	359,139	359,139	326,264	370,441	358,637	285,706
	Export	NA	281,750	338,850	297,118	354,750	329,890	269,715	209,143	316,695	232,405	256,314
	Value	282.9	234.7	247.2	244.8	336.4	331.1	472.6	296.7	613.5	540.7	419.1
CASHEW	Production	17,156	113,500	111,270	121,500	122,517	145,080	117,153	83,521	96,807	68,488	NA
	Export	78,415	82,185	77,418	95,925	112,925	109,915	113,891	97,628	66,380	74,757	57,826
	Value	11.4	136.4	138.7	148.1	172.8	173.9	242.8	221.0	207.4	272.0	160.9
TOBACCO	Production	NA	NA	11,066	11,949	14,481	13,025	18,150	14,193	19,126	18,265	17,087
	Export	NA	NA	6,947	4,783	5,396	6,116	8,831	6,372	11,184	11,561	11,294
	Value	NA	NA	44.8	43.1	49.2	55.5	88.1	82.3	NA	226.4	221.4
TEA	Production	NA	NA	8,492	10,457	12,706	12,658	12,974	13,732	14,074	10,415	10,946
	Export	6,700	7,638	6,900	8,324	9,707	9,505	9,652	10,456	12,612	12,984	14,942
	Value	45.0	48.0	42.0	49.0	53.8	45.2	69.1	81.2	134.5	177.8	168.0

Source: National Policy on Productivity, Income, and Prices, 1980.

[a]Production figures are given in metric tons.

[b]Value of exports given in millions of Tanzanian shillings.

Table 2.2

Sales of Cotton to Local Mills

YEAR	BALES[a]	VALUE[b]
1973-74	56,186	96.241
1974-75	61,579	108.505
1975-76	59,841	105.443
1976-77	56,253	100.232
1977-78	54,913	124.911
1978-79	66,669	174.326
1979-80	70,267	232.024

Source: Tanzania Cotton Authority, 1980.

[a]One bale is equivalent to 18 kilograms.

[b]Value of sales given in millions of Tanzanian shillings.

Table 2.3

Tanzanian Oil-Seed Crops: Value of Production[a]

1970 to 1977

CROP	1970	1971	1972	1973	1974	1975	1976	1977[b]
Castor Seed	8.7	7.9	8.9	10.3	4.7	5.6	3.0	2.7
Copra[c]	5.8	7.7	7.5	4.9	5.8	6.1	4.4	4.9
Cotton	52.1	43.0	66.5	72.3	68.2	32.6	86.7	75.6
Groundnuts	24.9	19.5	56.0	51.9	67.4	113.3	78.4	83.7
Sesame	11.4	10.0	9.8	12.9	19.7	22.1	18.7	20.0
Sunflower	2.1	2.3	6.2	8.7	11.5	16.5	20.2	21.2

Source: 1970-75: United Republic of Tanzania, Economic Survey, 1975-76, 1977, p. 60.

1976-77: United Republic of Tanzania, Economic Survey, 1977-78, 1979, p. 59.

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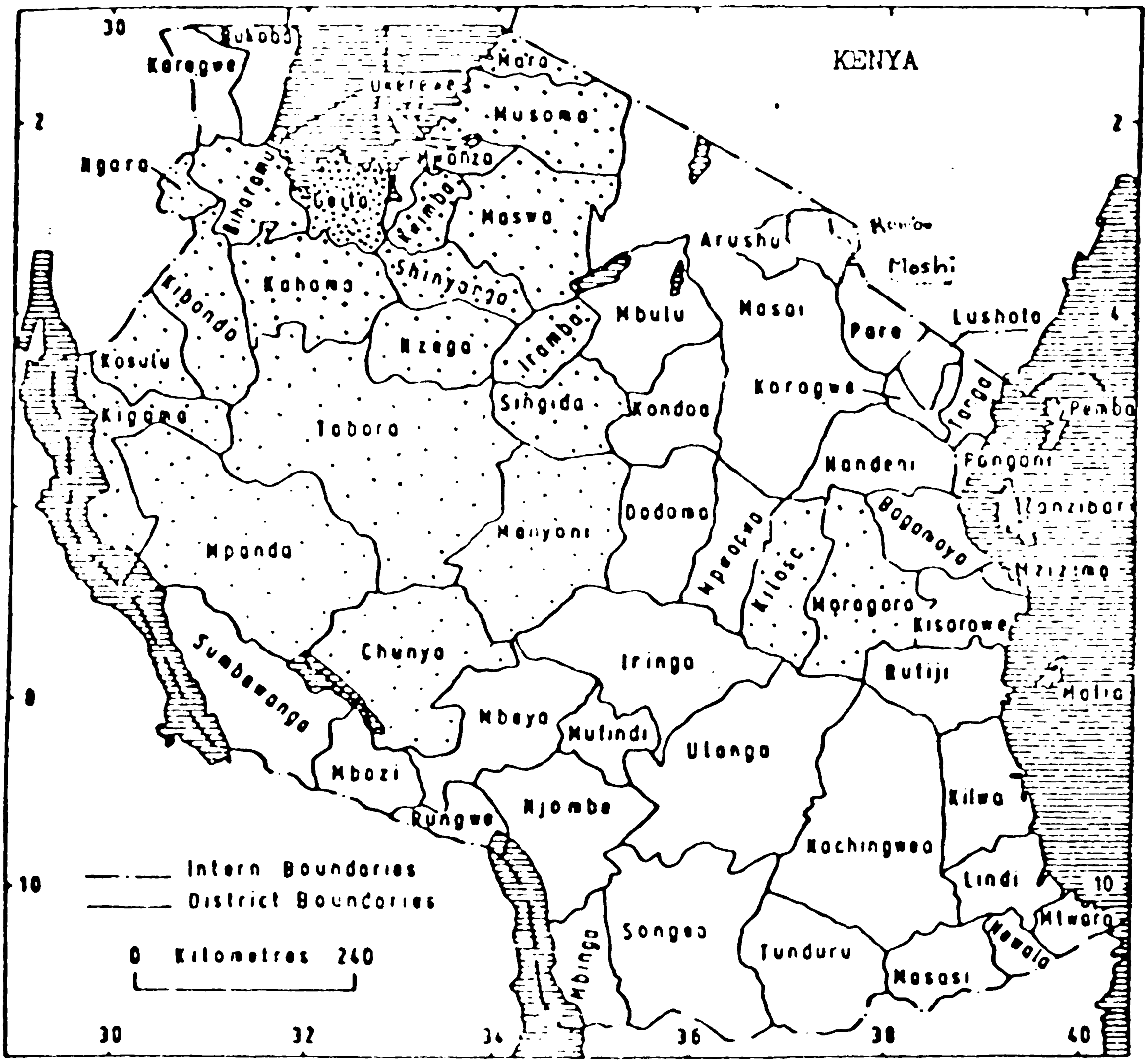
[a]Value of Production given in millions of Tanzanian shillings.

[b]Provisional figures as noted in the source.

[c]Value of marketed quantities.



Most important cotton-growing area

Other cotton-growing areas

Figure 2.1 Cotton-Growing Areas

Cooperatives, estimated that Mwanza and Shinyanga regions accounted for over 75 percent of the Cotton grown in the seven regions, with Mwanza producing slightly more than Shinyanga. Within Mwanza region, Geita is the most important cotton-producing district (see Table 2.4). Kwimba district is second to Geita.

In Geita, cotton is a very important cash crop for small farmers. In a sample of 89 farms, Collinson (1964) found out that average net income (cash and imputed value of household consumption) was Tanzanian shillings (Tshs) 1355.00 of which cotton sales accounted for Tshs 684.00 or 50.4 percent. Data collected by Larsen showed that cotton was the single most important cash crop for farmers in Geita district and in all Sukumaland, which includes both the Mwanza and Shinyanga regions. In 1968-69, Larsen estimated an average net farm income of Tshs 1974.00 for a sample of 219 farmers in Geita, Mwanza, Shinyanga, and Kwimba districts. Of this total income which includes the imputed value of household consumption, cotton sales contributed Tshs 497.00 or 33.7 percent. There is enough evidence, therefore, to show that cotton has a very important role to play in the Tanzanian economy and that Geita district is the most important producing area.

Production Patterns of Maize

An assessment of progress achieved in the food-crop sector is less easy to undertake than that of the export-crop sector because much of the output of many of these crops does not enter commercial-marketing channels. Sugar and wheat are more or less entirely commercialized, but rice and, to an even greater extent, maize are consumed on the farm.

Of the food crops produced and consumed in Tanzania, maize is by far the most important. The importance is illustrated in Figure 2.2 and Table 2.5. As shown in Figure 2.2, maize is the most important grain produced in the country. And, as shown in Table 2.5, of the four main food crops, maize is the most purchased and consumed. Maize is the main staple food consumed in urban areas. Most of what is purchased from the rural areas is sold to consumers in urban areas. Thus, when maize production falls below domestic demand, the government has to import it. Unfortunately, domestic demand for maize has often exceeded domestic supply. As shown in Table 1.1, the government spends some of its scarce foreign exchange on importing food in general and maize in particular.

The main maize-producing regions in Tanzania are Arusha, Dodoma, Iringa, Kilimanjaro, Lindi, Mara, Mbeya, Morogoro, Mtwara, Rukwa, Ruvuma, Tabora and Tanga (see Figure 2.3). Mwanza region as a whole is not a primary producing area. However, Geita district, which is in Mwanza region, is one of the most important maize-producing areas in Tanzania.

Although maize has been grown widely in Geita district for many years, it has been quite commercialized more recently. At the moment, there is a competition for resources between cotton and maize. In 1963-64 Collinson (1964) found that 90 percent of the households in his Geita sample grew maize and some cassava with legumes and/or sweet potatoes. Nkonoki estimated that about 95 percent of all farmers in the district grow maize.

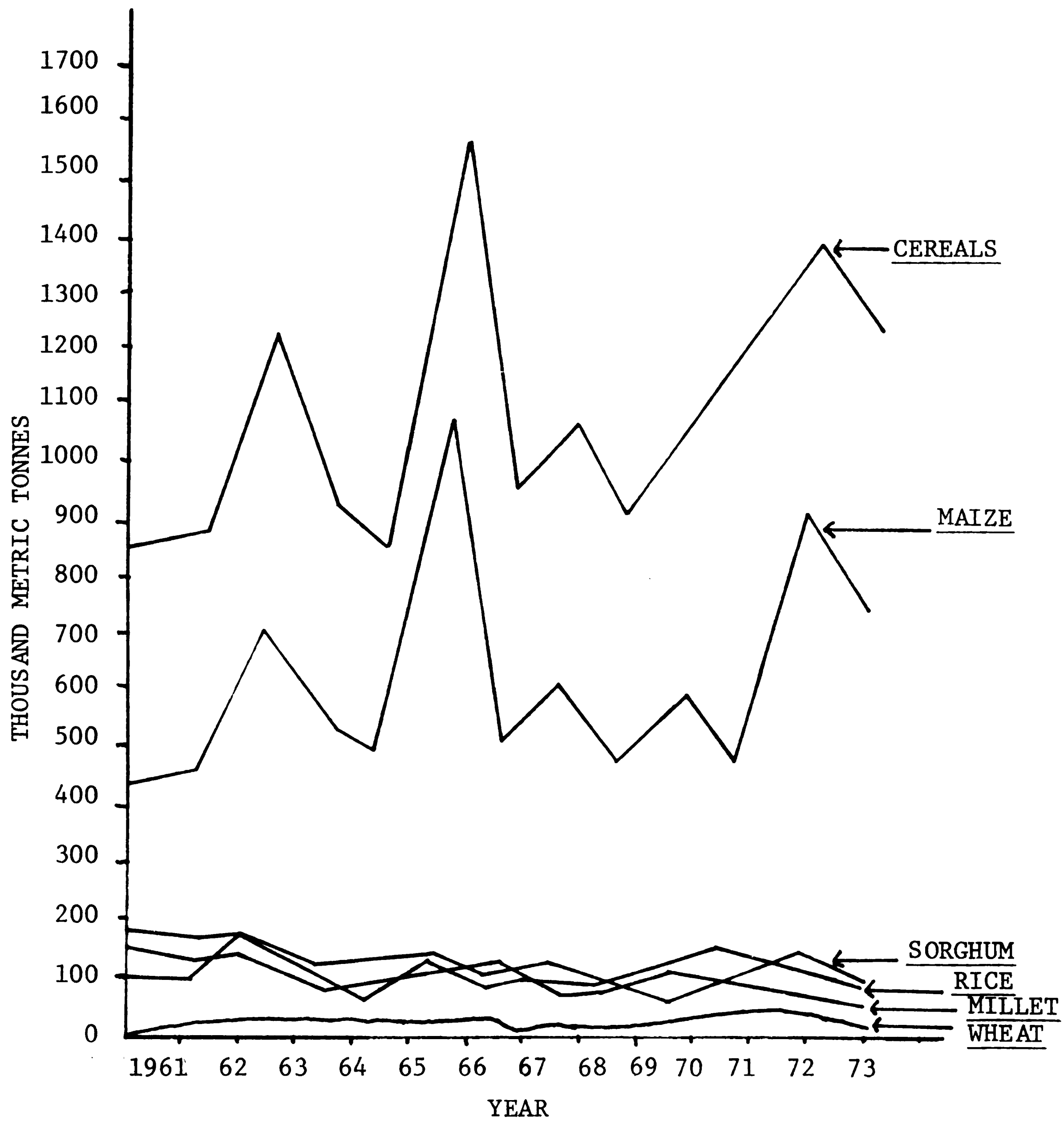


FIGURE 2.2 Grain Production in Tanzania

Table 2.4

Estimated Cotton Production 1969-70[a]

AREA	AMOUNT
Western Cotton-Growing Area	420,000
Mwanza Region	175,000
Geita District[b]	64,000
Kwimba District	62,000
Mwanza District	45,000
Ukerewe District	4,000
Shinyanga Region	160,000
Mara Region	45,000
Tabora Region	27,000
West Lake Region[c]	10,000
Singida Region	2,500
Kigoma Region	500

Source: Ministry of Agriculture, "Cotton Prospects" and "Preliminary Cotton Targets," (Mwanza: Tanzania, 1970), mimeographed.

[a]Cotton production expressed in 18-kilogram bales.

[b]Includes the new district of Sengerema.

[c]Now known as Kagera Region.

Table 2.5

Recorded Commercial Transactions of Main Food Crops[a]

FOOD CROP	1960-62 Domestic Supply	1960-62 Consumption	1960-62 Surplus (+) Deficit (-)	1970-72 Domestic Supply	1970-72 Consumption	1970-72 Surplus (+) Deficit (-)
Wheat	12	49	-37	50	64	-14
Maize	59[b]	NA	-	94	133	-39
Rice[c]	21	33[d]	-12	48	37	+11
Sugar	33[e]	60	-27	91	123	-32

Source: H.C. Kriesel, C.K. Laurent, C. Halpern, and H.E. Lazerele, "Agricultural Marketing in Tanzania, Background Research and Policy Proposals" (Michigan State University, East Lansing, June, 1970).

Ministry of Agriculture, Market Statistical Report, July 1973; Ministry of Economic Affairs and Development Planning, Second Five-Year Plan.

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[a]Transactions figures given in thousands of metric tons.

[b]This is recorded marketed quantities.

[c]An extraction rate of 65 percent was used to convert paddy into rice.

[d]Data for 1961 and 1962 only.

[e]Ex-mill, excluding jaggery.

Figure 2.3 Primary Maize-Growing Areas[a]

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[a]Represented by dots

Review of Relevant Studies

Although attempting to provide information for government policy makers, in most studies on agricultural production in small-farm economies little effort is made to analyze more than one crop--especially crops competitive in production. In addition, at times the whole problem is seen from the national point of view. Only secondary and aggregated data are used to analyze production problems of individual crops. A few such studies are reviewed below.

Malima discussed the impact on cotton production of agricultural research and extension, agriculatural infrastructure, agricultural pricing, and specialization and exchange. The role of extension services is to transmit research knowledge from research centers to the farmers. In practice, however, the coordination between research activities and extension services has not been effective. Malima cited two main problems with the various extension services. First there are not enough extension workers to visit the farmers regularly and advise them on better methods of cotton farming. Second, cotton farmers are illiterate and cannot utilize written extension materials. As Lewis put it, for most less-developed countries, a breakthrough in agriculture is "especially difficult because it is necessary to influence the decisions of hundreds of thousands of uneducated peasants" (p.45).

However, there is another problem that affects production of cotton. Quite a number of studies on cotton production pointed out that food production has a very important role in determining farmers' decisions regarding adoption of the "cotton package." In his study on the effectiveness and impact of improvement methods on small-farm cotton production in Mara region, Keregero concentrated on cotton production and the profit motives of farmers. He concluded that food production has a substantial impact on cotton yield. However, his conclusion was not supported empirically.

In another study on cotton production in Mara (Keregero, De Vries, and Bartlett) it was concluded that the real cost to the farmer of adopting the "cotton package" can only be determined by detailed micro-level study covering all major crops, including food crops. Unfortunately, this microstudy was not done.

In their assessment of recommendations for cotton production as applied by Niegerian farmers, Norman, Hayward, and Hallam found that "because a security strategy still plays an important role in farming decisions, the labor peak on a normal farm occurs in June and July when food crops are being tended" (p. 270). The authors also found, however, that where activity on unsprayed cotton began in July and was at a peak in August, there was virtually no demand on labor during June. Only when farmers adopted recommended practices and sowed their cotton in June was there considerable competition for labor. The competition would have been much greater had oxen not been employed. These results also showed that labor inputs (excluding labor involved in spraying) were on the average 94 percent higher for fields receiving recommended practices than for sole-cropped unsprayed cotton grown under indigenous conditions. Sixty-four percent of this increase came from the extra labor required to harvest the heavier yields resulting from the adoption of improved techniques.

Collinson (1972) pointed out that among small farmers "...an assured food supply and personal security needed to allow the productive activity to generate survival are extremely important" (p. 21). It follows that the quantity of supply, quality, preferred taste, and reliability of food supply are four specific motives dominating decision making and resource allocation in small-farm agriculture. On the other hand, Collinson argued that in any money economy it would be totally wrong to assume that small farmers would not be motivated by profits; this desire is necessary for further achievement.

Growth of agricultural output and productivity can be achieved in many ways. The government may invest in rural feeder roads, marketing and storage facilities, agricultural research, extension services, and increased water supply and may also provide cost-price incentives to farmers. These are necessary but not sufficient in themselves.

Based on numerous studies, some of which have been referred to above, it can be concluded that any policy that is intended to achieve national targets in agricultural output and productivity must address itself to understanding the behavioral characteristics of farmers. Farm management studies should be developed that deal with alternative farming systems that are technically feasible and economically profitable and that have the institutional, credit, tenure and cost-price incentives required to induce farmers to adopt new farming systems. Such studies would furnish indispensable information and data for economic-development planning and for implementing policy measures on the regional and national levels.

Cotton growing in Tanzania, and particularly in Geita district is management and labor intensive. Steps in growing cotton include land preparation; selection of seed variety and seeding rates, time of planting and planting operations; fertilizer application; spraying; thinning; weeding three to five times; picking; elaborate sorting of dirt from seed cotton before it is marketed; and uprooting and burning of residue. In Figure 2.4, these steps are summarized and compared with those for maize. Thus, since much labor is required for cotton growing, labor-saving techniques may be required.

Maize on the other hand, requires only two to three sessions of weeding and one or two applications of an insecticide. Labor requirements are comparatively fewer. The problem, however, is that cotton and maize compete for farm resources, particularly for labor. This competition for labor of cotton against food crops is especially apparent during the following farming operations.

Farming Operations

Land Preparation

Well performed land preparation insures a suitable bed for seed germination, provides young seedlings with a weed-free fertile environment, guards against erosion, and conserves moisture. Keregero found that land preparation requires large amounts of labor and that the required amount of labor is often not available because farmers put a high priority on the production of food crops especially maize. Percy identified the increased reliance on maize as the major factor accounting for late planting of cotton, since maize must be planted early to ensure food for the family.

COTTON			MAIZE		
Date	Operation	Technology	Date	Operation	Technology
Aug.-Sept.	Uprooting and Burning of Crop Residue	Manual	Oct.	Land Clearing	Manual
Oct.-Nov.	Land Tilling	Manual or Oxen or Tractor	Oct.	Land Tilling	Manual or Oxen or Tractor
Nov.	Ridging	Primarily Manual	Nov.	Ridging	Primarily Manual
Nov.-Dec.	Planting	Manual	Nov.	Planting	Manual
Jan.	First Weeding	Manual	Jan.	First Weeding	Manual
Feb.	Second Weeding	Manual	Feb.	Second Weeding	Manual
Early March	Third Weeding	Manual	Apr.-May	Harvesting	Manual
Early April	Fourth Weeding	Manual			
May-June	Harvesting	Manual			

Figure 2.4

Calendar of Crop Operations for Cotton and Maize

Time of Planting

Research at Ukiriguru (Peat and Brown) showed that timely planting of cotton is probably the most important single factor in increasing yields. Early planting on the average increased yields by 169 kg of seed cotton per hectare. In Figure 2.5, the relationship between cotton yield and planting date is shown. Early planting forms the base for many other practices in the recommended package. Returns from fertilizer and insecticide in late-sown cotton are far less than from early-sown cotton (Le Mare, 1969). However, early planting requires early land preparation and thus requires a large labor input, including fertilizer application, thinning and early weeding at a time when labor is scarce. At this time, most food crops have to be weeded, so farmers must either hire labor if it is available and they can afford it, or delay planting.

Weeding

Hulls found a close relationship between the time farmers spend on weeding and yields obtained. The recommended practice is to suppress weeds as soon as they appear. However, Keregero noted that this is the most labor-intensive activity in cotton growing and that it competes for labor with food crops.

Harvesting

The timing of cotton harvesting is very important because fibres in open bolls may be rained on and, hence, turn gray if left on the plant too long. On the other hand, the open bolls should be left on the plant for a few days to allow the fresh fibres to dry. Since all

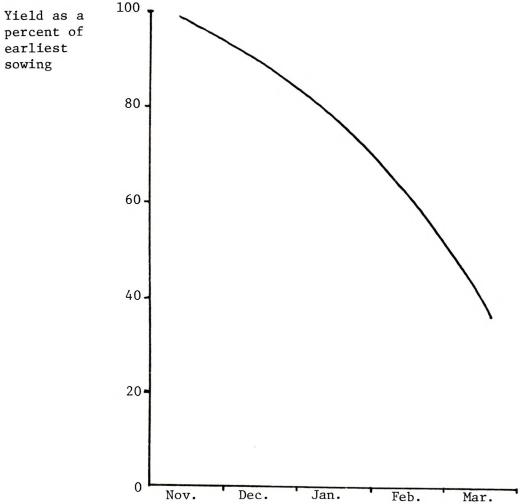

FIGURE 2.5 The Relationship Between Cotton Yield and Planting Date[a]

Source: W. Reed, "Problems Posed by Late Sowing of Cotton in Lake Region of Tanganyika." 1964, p. 256.

[a]Polynomial fitted to results from seven trials over seasons. R^2=0.74

bolls do not open simultaneously, more than one picking is necessary if all the cotton is to be picked at the proper time. Labor bottlenecks often occur during this period.

Shapiro outlined the timing of the various tasks involved in cotton production. The first labor peak is in the second half of November when ridging is done. Most land preparation is completed by mid-to-late December. After this until the end of April, weeding is necessary. Harvesting begins in mid-May and reaches a peak in June.

Labor allocation becomes clearer when one considers all the main crops. Collinson (1964) showed that peak periods of labor are November land-preparation peak, January weeding peak, and June harvest peak. The first two peaks coincide with the time when a great deal of labor is also devoted to food crops, especially maize. Shapiro noted two important consequences of this labor pattern. First, the coincidence of labor peaks for cotton and food crops strains the supply of family labor. Almost all hired labor in the area is for land-preparation and weeding. Second, if cotton were planted one half month earlier (a common recommendation) the peaks of cotton and food harvesting would coincide and thereby force many farmers to hire labor in late-April and late-May. This would be a third period of labor hiring, because the land preparation and weeding peaks probably would still occur (p.25).

This means that ways must be found to increase cotton and maize production, given the scarcity of labor (family, hired, and labor from working parties). Technologies that are labor saving or are substitutes for labor must be found. Mechanical technologies are the only substitutes for labor. Mechanical changes in agricultural technologies generally relate to the way in which agricultural tasks are performed by a variety of power-implement combinations. The major sources of farm power (human labor, animals, and mechanical sources such as the combustion engine for tractors and diesel engines or electricity for motors) and the implements with which these sources are used must also be considered. Thus mechanical innovations involve new farm-power sources and new implements and as such definitely change the ratios of inputs (man, animal, machine) being used in farm operations.

Mechanical innovations are not strictly independent of biological innovations i.e., the introduction of new inputs such as high-yielding seeds, chemical nutrients, pesticides, or new cultural practices such as crop rotations, new crops, crop calendars, and optimum timing of agricultural operations. However, in many practical instances, biological and mechanical innovations and their impacts can be treated separately. This is especially the case when it can be shown that the choice of a particular power-implement combination to perform any agricultural operation does not substantially affect the crop practices or yields. It is because of this that biological innovations have been labeled as land-saving and mechanical innovations as labor-saving, even though this is not strictly true.

In Geita, both biological and mechanical innovations are available. Field evidence however, indicates that mechanical innovations are unlikely to have any yield effects; that is, crop yields can be assumed to be invariant with respect to whether or not agricultural operations are performed manually, with oxen, or with tractors.[1] They are, therefore, treated in this study as separate technologies.

Another possible way of dealing with labor bottlenecks is by changing the cropping calendar. This would require much research and economic analysis to determine which crop should be planted early or late and what would be the impact of such a change on yields, farmers' incomes, and resource allocations. Such a farming system should then be compared to the existing one as well as to the application of mechanization. The comparison should be based on cropping patterns, total outputs, net farm incomes, and resource use.

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[1] Plowing or seeding with oxen or tractors does not raise yields. On the contrary, there is some evidence, though small, that deep plowing by oxen or tractors overexposes the soil, leading to moisture and fertility losses. The use of ridges preserves the moisture and is the most widely accepted innovation in Geita.

Agricultural Mechanization in Tanzania: Past Experience

There have been various attempts in the past to introduce mechanization in the form of tractor and oxen cultivation in Tanzania. These attempts were made with a view to relieving seasonal labor bottlenecks and raising labor productivity.

The early experiences of mechanization with the use of tractors indicated that, although it offered some benefits through more efficient use of labor--particularly where land was abundant and available by just clearing the bush, the costs were too heavy and could only be justified if mechanized farming led to sufficiently higher production, which often was not the case. The experiences of overcapitalized farm operations in Konjera, Urambo, and Nachingwea run by the Overseas Food Corporation and its successor, the Tanganyika Agriculatural Corporation, in the 1950s attest to these facts. Also, the lessons learned from the famous colonial groundnut scheme in Nachingwea (1952-56) in which 21 farms of between 200-600 hectares were mechanized are quite instructive.

The main problem with early mechanized farming centered on the high costs of European administration and management, machinery, declining soil fertility, and the variability in yields experienced in spite of intensive cash inputs such as fertilizers. The main advantages were two: the ability to perform timely operations and presumably the ability to bring more land under cultivation. Although it is possible to bring more land under cultivation by the use of tractors, it is not necessarily the cheapest way. In comparing the costs of bringing more land under cultivation (felling and clearing), Lord found manual methods to be clearly more economical than the use of bulldozers and tractors (pp. 125-129).

In spite of these lessons, interest in agricultural mechanization did not end. Several attempts were made later on. First there were the Settlement Schemes and the block-farm mechanization schemes of the early 1960s, which are well described by Taneja, and by the Bureau of Research and Land Use Planning. At the same time, there were attempts by the government to introduce tractor hire services through cooperative unions. With the policy to establish Ujamaa (Socialist) farming in 1967, there has been increasing free use of tractors in Ujamaa Villages through the Regional Development Fund (RDF) which provides a sum to each region each year for the purpose of effecting rural development. Taneja reported that in 1971 alone, the Tanzania Rural Development Bank (TRDB) loaned over 3.7 million Tshs for the purchase of tractors and other farm equipment to Ujamaa villages in various parts of the country. The experience of block-cultivation schemes is of special interest because of their apparent potential for socioeconomic development in line with the principles of Ujamaa.

By the late 1960s, the failure of tractor technologies was already apparent. A government study carried out in 1968 reported that "the experience with these tractors had been so bad that it must be recognized that the assumptions which were made at the time that they were introduced were wrong and no degree of tinkering with the organizational set-up can possibly make it work (Second Five-Year Plan, Appendix IV, p.12).

The main benefit of the failure of the tractor technologies was that many farmers turned to oxen cultivation. It was later concluded that "there was no case for the introduction of tractors in areas where ox-plowing is established, these can perform the same functions more cheaply" (Collinson, 1974) (p. 8).

The failure of tractor technologies led the government to look into the possibilities of the use of ox-powered equipment in the context of an agricultural sector dominated by small farmers and in a country where a large livestock population provided the potential for draft animals.[2]

Yet relatively little is known about the role of oxen technologies, particularly their potential within the context of the prevalent farming systems in Tanzania. Although the Tanzania Agricultural Machinery Testing Unit (TAMTU) was set up in Arusha in the early 1960s to look into these problems, its main function has been the testing and modification through field trials of a variety of farm machinery (including ox equipment) and the processing of equipment submitted to it by designers and manufacturers. Little attention has been paid to the development and

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[2]"We are using hoes. If two million farmers in Tanzania could jump from the hoe to the oxen plough, it would be a revolution. It would double our living standard, triple our product. This is the kind of thing China is doing." President Nyerere, quoted in W.E. Smith, We Must Run While They Walk, 1971. Also consider the more recent statements by President Nyerere: "...the truth is that the agricultural results have been very disappointing. Modern methods have not spread very widely; the majority of our traditional crops are still being grown by the same methods as our forefathers used.... People still think in terms of getting a tractor for their farms--even when they are small--rather than learning to use ox-ploughs." The Arusha Declaration: Ten Years After.

adaptation of these technologies in order to successfully deliver them to farmers. Certainly no detailed studies of the economic implication of alternative technologies at the farm level have been carried out.

The only way of ascertaining that oxen, as opposed to manual cultivation, were found economic in many cases was by the number of oxen plows purchased by small farmers in the year following this change in policy. In 1967, some 8,250 plows were bought; this increased to 9,100 in 1968 and to an estimated 15,000 by 1974. In some areas, particularly Sukumaland which includes Shinyanga and Mwanza regions, it also led to a significant increase in cotton hactarages and to an increase in farm incomes. It may also have generated additional employment although it was not possible to substantiate this.[3]

The government's cautious views on mechanization expressed after the failure of tractor technologices in the 1960s did not last long. They were overtaken by the events following the Iringa Declaration in May, 1972 and the general speeding of planned villages as well as Ujamaa villages, which took place from mid-1974 onward. The Iringa declaration put emphasis on the modernization of farming and farming techniques through gradual collectivization. This was interpreted in practice to mean development of villages through a promise to make tractors and other modern inputs available. Distribution of tractors to selected Ujamaa villages was, therefore, continued.

In 1974, a FAO mission reviewed the mechanization situation in Tanzania and found that the TRDB gave villages loans to purchase

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[3] See Clayton. However, the increase in hectarages on block farms cannot be attributed to use of oxen. See Collinson, "Cotton Development in Tanzania: A Review of the Cotton Program in Sukumaland" 1974.

tractors and that villages were allocated tractors purchased with rural development funds (RDF). Regions or district tractor-hire services operated by the regional authorities or by such parastatal organizations as the Tanzanian Cotton Authority were expanded. This was done even when villages were not capable of supporting tractor mechanization by subsidizing it in a variety of ways. These included the nonrecovery of loans made to cooperative villages, the semipermanent loan of tractors to villages that had neither the capacity nor the desire to meet any costs other than for fuel, the offering of uneconomic and subsidized sales of hire services and through the waiver of dues for hire services (FAO, P. 10).

On the other hand, the mission "found it extremely difficult to find any concrete evidence in the regions of a concerted effort to promote a wider and more intensive use of animal power. The program of establishing ox-training centers, mentioned in the Second Five-Year Plan (1969-1974) appeared to be virtually non-operative and little technical progress had been made at the village level beyond the use of the single harrow ox-plow (FAO, p. 9). The only exception was the work done by TAMTU in developing an improved and wider range of animal-drawn equipment and in fostering self-help at the village level by training artisans to manufacture simple equipment. However, as mentioned earlier, the impact of TAMTU was limited not only by other responsibilities given to it but also by the inability to either meet the demand through its own manufacturing or to distribute and provide services for the equipment it had tested or developed. Thus, in spite of the importance of oxen as sources of farm power in certain districts of Iringa, Shinyanga, Arusha, Mbeya, Mara, and Mwanza regions, there was "no area in which mechanization with oxen had progressed beyond the use of the simple harrow plows" (FAO, p. 13). Thus, in the Mission's view, "ox-equipment has yet to be given a real chance to prove itself, even in those districts where there is a tradition and aptitude for its employment" (FAO, p. 13).

More recently, the United Nations Development Program (UNDP) carried out a study that carefully compared manual-, oxen-, tractor-cultivation methods by using simple partial-budgeting techniques. This is one of the few available studies in which an attempt has been made to compare the economics of alternative forms of farm power, either manual, animal, or tractor, on the basis of carefully obtained cost data. It was concluded that both at the family-farm and Ujamaa-village levels, the promoting of comprehensive oxen techniques was most likely to offer the greatest advantages. It was also recommended that on larger, more successful Ujamaa villages, "well operated and maintained power equipment" used for minimal cultivation techniques offered the only feasible form of mechanization and that too in many cases in conjunction with oxen-cultivation" (Beeney, p. 5).

In short, past studies suggested that under current conditions, Tanzania should discourage tractor mechanization except in very special circumstances after careful study of its economic efficiency and viability. On the other hand, oxen cultivation should be further explored for its potential to relieve labor bottlenecks. However, there is some justification for additional studies on the subject.

First, the little evidence there is from past studies on agricultural technologies is based on partial budgeting methods by which the impact of various technologies outside and apart from the economics of the existing farming system (which include subsistence and cash crops as well as livestock activities that compete for farm resources and provide alternative sources of income and employment) are analyzed. It is important to know how different technologies will change the economics of such a farming system and not just whether or not a particular task can be performed or a particular crop grown at a lower cost by different methods. Partial budgeting methods fail to analyze the total farming system.

Second, past studies put emphasis on analyzing only the economics of various forms of mechanization. However, it is equally important to emphasize yield-increasing technologies based on the application of improved seeds, nutrients, pesticides, and cropping practices. Such an integrated approach to biological and mechanical technologies and their implication for the present farming system is needed.

Third, and particularly relevant to this study, is the need to make a comperative study of this subject in the context of both the household farm and block farming, which is now emphasized in Geita and other cotton-growing and tobacco-growing areas.

Block Farming and Mechanization

In the future, most cotton in Tanzania is expected to be grown on block farms. In block farming, each household owns farms that are arranged close to farms owned by other households. The household farms are separated by foot paths, and each block may hold from 20 to 40 hectares. The economic considerations of block farming are as follows:

1. When farms are close together, they can be more effectively attended by a small number of extension personnel. Improved husbandry techniques, such as early planting, fertilizing, and spraying, can be demonstrated on the participants' own plots.

2. It is more economical and easier to mechanize such farms. Capital is a scarce production factor in Tanzania. Consequently, there is little economic advantage in substituting capital for labor. The main justification for the use of tractors is that they can supplement already fully engaged family labor in the most labor-intensive operations. In other words, rather than have 50 families cultivate four hectares each, it would be desirable to have more participants who would own one, two, or even more hectares on the block.

3. With regard to vermin, one farmer can look after 20 or so hectares of cotton or maize per day on a ratational basis, instead of each farmer looking after his own farm throughout the season.

4. Block farm schemes are also expected to insure economic and proper land use and provide a much needed check against soil erosion.

Politicians view block farming as an approach that takes the rural sector one step nearer to communal farming--an ultimate objective of Tanzania's socialist policies.

Past Experiences in Mechanized Block Farming of Cotton

In 1964-65, the government introduced block cultivation schemes in Mwanza and Shinyanga regions. In that year, the government turned over to the then Victoria Federation of Cooperative Unions 159 tractors. The main objective of establishing block-cultivation schemes was to help farmers use tractors economically by consolidating cotton cultivation into large blocks. The main assumption in which farm blocks were established was that labor was scarce in these regions and that additional land could only be cultivated if tractors were used to complement the labor. Another assumption was that close supervision would improve farming practices. For example, the use of fertilizer could be readily demonstrated by the extension service with resultant improved yields. Klien, Green, Donahue, and Stout reported that increases in cotton yields from around 450 to 1100 kg per hectare were anticipated through the supervised use of fertilizers, insecticides, and greater cotton varieties. A third assumption was that economies of scale could be effectively realized if the land were farmed in large blocks. Between 1963 and 1965, the government imported about 673 tractors and distributed them to cooperative unions throughout the country to use on a hire-service basis.[4]

The outcome of the scheme was disastrous. A study by Amarshi revealed that out of the 41 cooperative unions involved, only one achieved any measure of success and about 65 percent of the Tshs 18 million spent on the scheme plus Tshs 2 million of arrears in interest

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[4]Although the regional distribution was fairly widespread, nearly 41 percent of the tractors (277) were given to Mwanza and Shinyanga. See Report of Working Party No. 12 on Agricultural Mechanization, Second Five-Year Plan, June 1968. Appendix 1.

payments were never recovered from the unions. Even "the one successful cooperative union...foresaw the difficultires of running a hire-service and, therefore, sold the tractors to its richer members instead, on a hire-purchase basis" (Amarshi, p. 69).

A number of studies cited the several factors that led to the failures as follows: poor organization, inadequate skills for repair and maintenance, unproductive and inefficient use of machines, high costs of clearing land and inadequate increase in production. Klein, Green, Donahue, and Stout noted that in Mwanza and Shinyanga regions, supervision proved to be extremely difficult. This was so even though 40-65 percent of all extension workers in the country were employed on the scheme and only a handful of the total farmers in the two regions were affected. In addition, in spite of basing standard depreciation estimates on 1,200 operating hours per tractor per annum, constant losses were experienced on tractor operations due to inefficient or inadequate use.[5]

Pupius argues that the form of agriculture under the block schemes involved a shift from "low cost production, profitable with low returns, to high cost production requiring high returns" (p. 4). Under the block-farm schemes, a substantial improvement in crop yields was required. Yet, as Heijnen found out, the yields were far lower than anticipated and varied enormously between various blocks and

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[5] Collinson (1964, p. 6) estimated a range of between 575-825 tractor operating hours per annum, but evidence suggested that tractors did not reach even this level of operation. De Wilde (1967, p. 439) noted that of the 16.5 thousand hectares on 50 block farms, only 33 percent was cleared and 19 percent planted, amounting to an average of 27 hectares per tractor of planted area.

individual plots within blocks. He came to a conclusion that in order to meet the higher level of operational costs, cotton yields of between 925-1200 kg per hectare were required. But cotton yields varied between 300-465 kg per hectare in Mwanza and Shinyanga regions. In many cases, these could not even cover the cultivation costs. Heijnen recommended that in order for higher yields to be achieved, mechanization of agriculture should go hand-in-hand with the following:

1. Establishment of good soil fertility on block farms.
2. Areas selected should be suitable for cotton-growing and mechanical cultavation.
3. Good crop husbandry would be necessary; i.e., late planting, poor and late weeding and/or thinning, inadequate fertilizing, and expensive spraying must be avoided.

In other words, yeild-increasing technologies must be emphasized when a shift is made from low-cost production, profitable with low returns, to high-cost production requiring high returns.

Tillage Tools Used in the Production of Cotton, Maize, and Other Crops

There are three distinct groups of farming tools in Tanzania: (1) primary tillage tools; (2) secondary tillage tools; and (3) weeding tools. Each of these is discussed below.

Primary Tillage Tools

These tools are used to break and open up the land for subsequent operations. These tools include:

1. Hand hoes. Hand hoes are used by many farmers in the country. Where ridge cultivation is common, such as in Mwanza and Shinyanga regions, the general practice is to push all of the trash in the furrow previously made. Then ridges are reformed on these furrows when the trash is completely covered. Where plain cultivation is practiced, the trash is first collected and burned before the land is tilled. This practice, beside leaving the soil unprotected from erosion and sunshine, also increases organic matter decomposition. With careful tilling and avoidance of burning, it is possible to have a somewhat rough and trashy field. The tool, however, limits extensive crop production because of low capacity and high human-power requirements.

2. Mouldboard plows. Presently, this is the only animal-pulled tool used for primary tillage operations. The plow cuts, shatters, and inverts the soild. Thus, it can pulverize the soil, but the extent of pulverization depends on among other factors, the type of the mouldboard. The tool requires very little trash, if any, in the field for efficient operation. What trash exists is turned under and covered by the soil. Hence soils from a field worked with this tool are unprotected from rain and sunshine, leading to erosion and loss of moisture by evaporation. Also such a condition is ideal for quick decomposition of the organic matter. Moreover, the operation of this tool is limited in areas with heavy soils and moisture because of that stickiness or hardness. In relatively light soils, this plow can operate when the soil is dry. The result can be big clods that are useful for protecting the soil from wind erosion.

Although there have been attempts by the Ubungo Farm Implement Manufacturing Company (UFI), set up in Dar es-Salaam in 1970 with Chinese aid to manufacture agricultural tools, to produce a mouldboard plow that can work successfully under all conditions, variations in local conditions have made it impossible.

3. Disc plows. This plow requires tractor power. Like the mouldboard plow it cuts, shatters, and inverts the soil. But unlike the mouldboard plow, it leaves rough seedbeds and it can work under stumpy, stony and trashy conditions. The disc plow covers the trash in the field but not as completely as the mouldboard plow.

4. Heavy-duty disc harrows. Harrows are sometimes used to open up land. A harrow consists of two or more gangs of discs usually pulled behind a big tractor. The tool pulverizes the soil more than the disc plow does. It requires large tractors with high horse-power output. The whole system--tractor and harrow--is very heavy and can compact the soil, rendering it impermeable.

5. Chisel plows. In some parts of Tanzania, chisel plows are common tools for primary tillage. This kind of plow consists of a framework on which either spring tynes of rigid shanks with soil-working points are attached. The soil-working points are the pointed-teeth duck feed and sweeps. The chisel plow cuts and shatters the soil but does not invert it. It can work in fields with trash without covering the trash, so it is a useful tool for protecting the soil from erosion and sunshine.

6. Rotavator. The rotavator is not a common tool among small farmers, but it can be found on some of the state farms. Where fields have previously been cultivated, it is used for primary tillage; otherwise it

is used in secondary tillage operations. It cuts and pulverizes the soil, and it also incorporates the trash. Susceptibility of the soil to wind and water erosion is increased when this tool is used. In addition, decomposition of organic matter becomes rapid. Moreover, high power is needed for operation of this tool.

7. Ridgers. The ridger is mounted on a tractor or pulled by animals. It is used to make ridges either on cultivated or uncultivated land. The ridger cuts and inverts the soil also but not to the same extent that the mouldboard plow does. If properly used, it can leave some amount of trash on the surface of the field.

Secondary Tillage Tools

These tools are used after primary tillage to pulverize the soil more, kill weeds, level the surface, and pack the soil into a firm seedbed. The goal is to have a smooth trash-free field ready for planting. Mechanical planters, in large-scale farms particularly, are designed to work on such well-prepared fields. The tools commonly used for secondary tillage include the following:

1. Disc Harrows. These harrows are available in various sizes but are generally divided into trailing and mounted disc harrows. They are used to pulverize the soil more, leaving it in a fine tilth for the reception of the seed. So they cover most of the trash, compact the soil, and destroy the soil's physical properties. This leaves the soil very susceptible to erosion, loss of water by evaporation, and high organic-matter decomposition.

2. Tyne harrows. These harrows consist of a frame on which teeth are attached. In spike-tooth harrows, the teeth are pointed and rigid, whereas in spring-tooth harrows, teeth are curved and have a spring mechanism. The spring-tooth harrows work efficiently even in rough and trashy conditions. But harrows break the soil clods, creating a fine seedbed. These harrows, and especially the spike-tooth harrows, have a tendency to rake the trash.

3. Rotavators. These tools thoroughly cut and mix the trash while pulverizing the soil more. They create a condition for rapid organic-matter decomposition and also destroy the soil's physical properties, leading to more erosion by water and wind.

Tools for Weeding

For weeding purposes, there are tools called cultivators. Unfortunately, these tools are inadequately developed in Tanzania not only on small-scale farms but also on large-scale farms. The few that are available often lack steering and easy adjustment. Because of this, destruction of crops by ripping is common. Weeding tools extensively used in Tanzania are as follows:

1. Hand hoes. The most common hand hoes are light and short. Depending on how they are used, they can produce a rough trash field suitable for controlling soil erosion. But because of their high human-power requirement, their capacity is limited to a few hactares.

2. Tyne implements. Like the chisel plow, these tools consist of a framework on which shanks are attached to suit the crops to be weeded. The soil-working points are fixed. For this kind of implement, there must be completely trash-free conditions to avoid clogging and ripping

off the crop. Their ground clearance is often not enough, causing easy clogging. Thus, they are efficient for weeding only in early stages of the growth of the crop.

With enough ground clearance, the sweeps fitted to the shanks have proved to be successful in working in trashy fields. They penetrate the soil and cut the roots of weeds with very little, if any, inversion and coverage of the trash. Unfortunately, these implemetns are seldom used in Tanzania.

3. Ridgers. Ridgers are found only in a few areas of the country. Although their main function is to make ridges, they can also be used as weeding tools. They form small ridges on the crop rows covering the weeds within the rows. But in a young crop where there is no proper vegetative cover, the soil is exposed to sunshine and raindrop impact.

There are three main conclusions that can be drawn from the discussion of farm tools in Tanzania. First, most of the tools are primarily used in preparing the land for planting. Other farm operations, such as weeding, still depend on manual technologies, with the hand hoe playing an important role. Second, many of the tools require literate farmers who can use the tools properly so as to avoid negative impacts on their soils. Lastly, some of the tools, especially those requiring large tractors with high horse-power output, are unlikely to be profitable on small farms. This then calls for further consideration of policy issues related to mechanical technology for small farms that experience labor bottlenecks in some farming operations.

CHAPTER III

THE AREA SELECTED FOR THE STUDY

The data for this thesis was collected from Geita district[1] during the 1979-80 farming season. A sample of 80 farm households was selected for this study. In this district, cotton is the main export crop, whereas maize is the main food crop.

Description of the Geography and Climate of the Study Area

Location, Size, and Topography

Geita district lies between 2^{o} and 3^{o} south latitude, and 32^{o} and 33^{o} east longitude. It is bounded on the west by Biharamulo district, on the east by Smith Sound (a part of Lake Victoria), on the north by Lake Victoria, and on the south by Kahama district. It is estimated that Geita has a total land area of 9067 square kilometers. Much of the district is characterized by gently rolling hills or ridges, which lie approximately 1220 to 1370 meters above sea level.

Climate

The district receives an annual rainfall of between 940 and 1190 mm. This amount of rainfall is generally more than that received by areas to the east, where the Ukiriguru Research Center has recorded a 37-year average annual rainfall of 847 mm. The rainfall pattern is marked by definite dry and wet seasons, the latter showing a slight bimodal distribution. Early rains begin in late August and September. The first peak is reached in November or December, followed by a slightly

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[1] In this study, Geita district includes Sengerema district, which was recently created from a larger Geita area. Both districts are equally important for cotton and maize.

less wet period in January and February. The second peak comes in March or April followed by a decrease in rainfall and then the dry season in June and July.[2]

This rainfall districution (see Table 3.3) is well suited to cotton farming, which needs about 760 mm of rain during its six-month growing season. Cotton planted in late November or early December most likely receives the proper rainfall distribution and thus avoids damage that rain can cause to exposed cotton fibres.

The temperature in Geita is good for agriculture. Anthony and Uchendu noted that during the cropping season, the mean maximum temperature at nearby Ukiriguru is about 83^{o}F and the mean minimum is about 63^{o}F. During July, the coldest month, the mean mimimum is 58^{o}F.

Soils. Most soil in the district is derived from granite and is of a sandy nature. Generally, the soils are of average fertility. Malcolm listed the following soil types in the granitic catena in order from the top: isanga, kikungu, luseni, itogoro, mbuga (local names). Samki gave the same list but labelled the highest layer skeletal soil rather than isanga.

Isanga is described as "a coarse-grained sandy to gravelly soil of a light reddish colour derived from granite with sporadic laterite, which is a red ferruginous rock forming a surface or subsurface covering in some areas" (Malcolm, p. 176). The soil is said to be the most favorable for Bambarra nuts and is also suited to sweet potatoes, millet, cassava, and groundnuts.

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[2] The rainfall pattern in Sengerema, Geita Town, and Ukiriguru weather stations is shown in Table 3.1. The mean annual rainfall for Geita and Sengerema districts are shown in Table 3.2.

Samki described Kikungu soils as being "dark brown to dark reddish brown, loamy sand to sandy loam...(with) low holding capacity" (p. 1). These soils show an advanced stage of weathering. Kikungu and luseni are the most important for cotton growing. Kikungu is also suited for cassava, millet, sorghum, groundnuts, and bambara nuts.

Luseni is a grayish brown fine sand that is low in organic matter and is strongly leached. Apart from being suitable for cotton, Luseni is also suited for cassava and sweet potatoes. Itogoro is a sandy clay-loam that is very soft when wet and forms a thin hard crust when dry. It is the most favorable soil for cowpeas and is also suitable for sorghum, cotton and sesame. However, itogoro is hard to work and is now used mainly for grazing.

Samki described mbuga as being a clay or a clay-loam; the water table is close to the surface and impedes drainage. Mbuga is high in organic material and receives nutrients from the soils higher on the slope. This soil is usually wet and hard to work in the rainy season. Where it is found, mbuga soil is used for rice growing and grazing.

In 1966, the Ministry of Economic Affairs and Development Planning claimed that of the 1,018,000 hectares of land in the district, 909,000 hectares were cultivable, 100,000 were in forests, and 9,000 were primarily very rocky or swampy areas. Fifty percent of the 909,000 cultivable hectares was cited as having good soils (such as luseni, itogoro, and kikungu) that would need little work prior to normal land preparation. The other 50 percent was listed as having exhausted soils, heavy clays that present problems to current technologies, waterlogged soils, or soils overrun with weeds. The recent estimates of land and water areas,

Table 3.1

Monthly Rainfall at Sengerema, Ukiriguru, and Geita Towns[a]

MONTH	SENGEREMA[1] 1969	SENGEREMA[1] 1970	UKIRIGURU[2] (avg. for 1931-October 1967)	GEITA TOWN[3] (period not specified)
January	173.44	101.53	95.71	101.28
February	184.32	79.76	89.63	84.32
March	193.44	111.66	128.62	120.77
April	86.85	188.38	145.59	155.72
May	114.69	84.57	68.87	87.35
June	0.51	0	8.86	11.14
July	0	0	2.03	1.01
August	0	72.67	11.90	12.41
September	76.72	33.93	23.04	31.90
October	18.99	66.84	46.84	85.33
November	150.40	109.64	114.69	136.47
December	109.64	111.66	111.66	122.04
Annual Total	1,110.03	989.76	847.46	949.50

Sources: [1]Unpublished daily rainfall records at the Sengerema sub district station of the Tanzania Ministry of Agriculture (K. Shapiro).

[2]Cotton Research Corporation, "Progress Reports from Experiment Stations, Season 1967-68, Tanzania Western Cotton-Growing Area," 1969, p.4.

[3]M.P. Collinson, "Farm Management Survey Report No. 4," p.3.

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[a]Rainfall figures given in millimeters. One millimeter is equal to 0.0394 inches.

Table 3.2

Mean Annual Rainfall 1973-78 in Millimeters and Days[a] of Rainfall

DISTRICT	1973		1974		1975		1976		1977		1978		SIX-YEAR MEAN RAINFALL	
	MM.	# of Days	MM.	# of Days	MM.	# of Days	MM.	# of Days	MM.	# of Days	MM.	# of Days	MM.	# of Days
Geita	736	57	644	73	960	67	704	52	1,382	80	750	40	863	62
Sengerema	914	70	732	66	1,163	83	462	29	966	76	2,860	52	1,183	63
Annual Mean Rainfall	825	64	688	70	1,062	75	583	40	1,174	78	1,805	46	1,023	62

Source: Geita Cotton Project, "Project Evaluation Report for 1978-79 and 1979-80," p.5.

[a] Recorded days of rainfall.

Table 3.3

Seasonal Distribution of Rainfall since 1975 in Millimeters

SEASONS	20-YEAR AVERAGE			1975			1976			1977			1978			4-YEAR AVERAGE		
	(a) Total (MM.)	(b) Monthly Average (MM.)	(c) (b) as % of (a)	(d) Total (MM.)	(e) Monthly Average (MM.)	(f) (e) as % of (d)	(g) Total (MM.)	(h) Monthly Average (MM.)	(i) (h) as % of (g)	(j) Total (MM.)	(k) Monthly Average (MM.)	(l) (k) as % of (j)	(m) Total (MM.)	(n) Monthly Average (MM.)	(o) (n) as % of (m)	(p) Total (MM.)	(q) Monthly Average (MM.)	(r) (q) as % of (p)
OCT.-DEC. SHORT RAINS	362	120.7	37.7	469	156.5	38.4	362	120.7	36.6	565	188.3	40.6	482	160.7	33.7	470	156.5	37.4
JAN.-FEB. SHORT DRY PD.	212	106.0	21.1	109	54.6	8.9	160	80.1	16.2	200	99.8	14.4	269	134.4	18.8	184	92.2	14.6
MAR.-MAY LONG RAINS	326	108.7	34.0	329	130.6	32.1	385	128.4	38.9	498	166.2	35.8	469	156.4	32.7	436	145.3	34.7
JUNE-SEPT. DRY PERIOD	60	15.0	6.2	251	62.8	20.6	82	27.5	8.3	129	32.2	9.2	212	52.9	14.8	168	42.1	13.3
TOT.	960	80.0	100.0	1,221	101.8	100.0	989	82.4	100.0	1,392	116.0	100.0	1,432	119.3	100.0	1,258	104.9	100.0
ANL TOT. AS % OF 20-YR. AV.	100			127			103			145			149			131		

Source: Geita Cotton Project, 1980, "Project Evaluation Report for 1978-79 and 1979-80," p.7.

and land distribution within the Geita Cotton Project are shown in Tables 3.4 and 3.5 respectively.

Population

The 1978 TAnzanian Census reported a total population of about 17.5 million. Of this population, 558,500 live in Geita district (including Sengerema). The census reported an overall population density in Geita district of 61.5 people per square kilometer. However, the density is generally actually higher since the population is concentrated in villages that were established during the 1974-76 period. Most of these villages are found along roads. The average household size in the country is 4.7 people, whereas that in Geita is 7.1. It is estimated that there are 86,000 farms in the area. In Table 3.6 is summarized the population of Geita since 1934. In Table 3.7 is summarized the 1978 population distribution by age and sex. It is clear from Table 3.6 that, since the population in 1978 was tentimes more than that of 1934, the average area of land per person decreased by 90 percent. The growth in population was due to migration of people from the dry areas of Shinyanga and Mwanza regions.

There are three important occupations that influence the settlement pattern; these are agriculture, by far the most important; trading; and mining. Geita and Sengerema twons, with populations of a little more than 7000 and 13000 respectively, are the main urban settlements. They are also the administrative headquarters of the two districts.

Table 3.4

Estimated Land and Water Areas[a]

AREAS	GEITA		SENGEREMA		TOTAL AREA	
	km²	% of Total Area	km²	% of Total Area	km	% of Total Area
Total Land Area	6,752	69.6	2,315	32.5	9,067	53.9
Total Water Area	2,953	30.4	4,817	67.5	7,770	46.1
Total Area	9,705	100.0	7,132	100.0	16,837	100.0
Cultivable Land	3,078	31.7	1,328	18.6	4,406	26.2
Grazing Land	3,674	37.9	987	13.8	4,661	27.7
Total Land	6,752	69.6	2,315	32.5	9,067	53.9

Source: Geita Cotton Project, "Project Evaluation Report for 1978-79 and 1979-80," p.2.

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[a]Areas given in square kilometers.

Table 3.5

Land Distribution by District

ITEM	UNIT	GEITA	SENGEREMA	TOTAL
Total Land Area	km^2	6,752	2,315	9,067
Cultivable Land	km^2	3,078	1,328	4,406
Families	No.	48,183	41,056	89,239
Population	No.	307,233	251,283	558,516
Family Concentration	No. Per km^2	7.1	17.7	9.8
Population Density	No. Per km^2	45.5	108.5	61.5
Cultivable Land Per Family	Hectares	6.39	3.24	4.93
Total Available Land Per Person	Hectares	2.19	0.93	1.62

Source: Geita Cotton Project, "Project Evaluation Report for 1978-79 and 1979-80," p.3.

Table 3.6

The Population of Geita Since 1934[a]

YEAR	POPULATION ('000)	POPULATION DENSITY (per square km)	AVERAGE SIZE OF LAND Per Person (in hactares)
1934	55.8	6.2	16.23
1944	87.2	9.6	10.40
1947[b]	108.2	11.9	8.38
1957[c]	270.0	29.8	3.36
1960	285.0	31.4	3.19
1966	320.0	35.3	2.83
1967[d]	330.0	36.4	2.75
1970	371.4	40.9	2.42
1978[e]	585.5	61.5	1.62

Source: Bureau of Statistics, Statistical Abstract, 1980.

[a]Projected estimates

[b, c, d, e]Based on respective year population census.

Table 3.7

Sex and Age Distribution of Population by District[a]

AGE GROUPS (in years)	GEITA				SENGEREMA				TOTAL POPULATION				
	Males	Females	Total of the Group	% of Total Pop.	Males	Females	Total of the Group	% of Total Pop.	Males	Females	Total of the Group	% of Total Pop.	Females Per 100 Males
0-9	54,815	56,966	111,781	36.5	42,026	43,004	85,030	33.9	96,841	99,970	196,811	35.2	103
10-24	43,266	45,812	89,078	29.0	33,572	35,290	68,862	27.5	76,838	81,102	157,940	28.3	106
25-34	21,148	21,625	42,773	14.0	16,292	15,900	32,192	12.7	37,440	37,525	74,965	13.4	100
35-54	22,738	20,851	43,539	14.0	29,760	18,051	47,771	19.1	52,458	38,902	91,360	16.4	74
55 and Over	11,467	8,545	20,012	6.5	9,743	7,685	17,428	6.8	21,210	16,230	37,440	6.7	77
Total	153,435	153,799	307,233	100.0	131,353	119,930	251,283	100.0	284,787	273,729	558,516	100.0	96

Source: District Development Office, Geita and Sengerema, unpublished reports.

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[a]Based on 1978 population census.

Agriculture

The physical environment--rainfall, temperature, topography, and soils--of Geita permits a variety of crops to be grown. However, the most important crops are cotton, maize, and cassava. Cattle and other livestock such as sheep and goats are kept by many households, but not much use is made of their manure nor their draft power. The long-handled hoe is the universal cultivation tool. Shapiro in his research sample of 76 noted that no farmer used an ox plow. There is a small number of privately owned tractors available to private farmers on a hire basis, but their use is very rare; in Shapiro's research sample, only one farmer hired a tractor. Because of foreign-exchange problems and the government's deliberate policy of controlling tractor-hire services, even the small number of privately owned tractors has sharply decreased. Most tractor-hire services are now provided by the Geita Cotton Project (see Appendix A).

Main Crops

As previously mentioned, cotton is by far the most important cash crop in the district. Maize and cassava are the two most important food crops, followed by sweet potatoes and rice. Legumes, such as groundnuts, beans, and cowpeas, as well as garden crops, such as cabbages, tomatoes, bananas, and citrus fruits, supplement the above-mentioned starchy food. All food crops also serve as cash crops although in a minor way for most farmers. From 1975-79, however, maize was highly commercialized. Food shortages in the country coupled with the government's emphasis on increased maize production in the area led to a competition between cotton and maize. Allocation of land to major crops has changed somewhat in the last decade or so (see Table 3.8a). Currently, the crop mixture is slightly different (see Table 3.8b). Since the move to planned villages in 1974, followed by the government's direct involvement in land allocation and emphasis on maize production, many farmers now grow maize as a single crop. Millet and sorghum have become less important among the starchy staples. Collinson reported that only 5 percent of his Geita sample grew either millet or sorghum. Shapiro found that less than 10 percent of the farmers in his ample grew either. In the sample for this study, no farmer grew millet or sorghum.

Cultivation Practices

Most, if not all, farmers plant their crops (except rice, vegetables, and fruits) on top of ridges that are about 5 feet apart and about 18 to 24 inches high. The exact dimensions differ from crop to crop, those for cassava being greater than those for cotton. Although ridge cultivation is very labor intensive, it has many benefits.

After harvesting, previously cultivated land is left untouched until the rainy season is about to start. Then the farmers clear off the weeds and other plant materials and put them into the furrows to dry. The old ridges are then split in the middle and hoed into the furrows on either side. The weeds and other plant materials that had been hoed into the furrows are buried and the field is leveled. As the rainy season begins, new ridges are built up over the dead weeds in the furrows of the former ridges.

All farmers practice ridge cultivation. It is a traditional practice in Shinyanga and Mwanza regions. The government has not attempted

Table 3.8a

Allocation of Land to Major Crops[a]

CROP OR MIXTURE OF CROPS	PERCENTAGE OF FARMS GROWING THE CROP(S)	MEAN OVER SAMPLE (hectares)	MEAN OVER GROWERS (hactares)
Cotton	93	1.61	1.73
Maize and Cassava with Legumes and/or Sweet Potatoes	90	1.11	1.23
Maize with Legumes and/or Sweet Potatoes	46	0.44	0.95
Rice	42	0.11	
Old Cassava	40	0.43	0.26
Sweet Potatoes	24	0.04	1.08
Cassava with Legumes and/or Sweet Potatoes	13	0.07	0.55
Sorghum or Millett with Legumes and/or Sweet Potatoes	5	0.05	1.01
Total		3.86	6.96

Source: M.P. Collinson, "Farm Management Survey Report No. 4," p.8.

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[a]Average hectarage per farm in Lwenge Primary Society Area, Geita district, 1963-64, sample of 89 farms.

Table 3.8b

Allocation of Land to Major Crops

CROP OR MIXTURE OF CROPS	PERCENTAGE OF FARMS GROWING THE CROP(S)		MEAN OVER SAMPLE (hectares)		MEAN OVER GROWERS (hactares)	
	P	NP	P	NP	P	NP
Cotton	100	100	1.29	1.25	1.29	1.25
Maize	100	100	1.23	1.38	1.23	1.38
Cassava with Legumes	87	89	0.24	0.26	0.27	0.39
Cassava	61	69	0.19	0.20	0.48	0.61
Sweet Potatoes with Legumes	44	36	0.14	0.10	0.63	0.55
Vegetables	28	31	0.03	0.04	0.10	0.18
Total			3.12[a]	3.23	4.00[a]	4.36

Source: Computer from survey data.

[a]These areas exclude 0.73 hectares of uncultivated land that was part of 3.25 hectares allocated for growing cotton and maize.

to change this practice; for it is beneficial to crop growth and erosion control. Shapiro listed some of the benefits of ridge cultivation as follows:

1. Imporved weed control from burial of the previous year's weeds.
2. Use of weeds and other plant matter as compost.
3. Thorough, deep working of the soil.
4. Easier weeding.
5. Increased water-absorbing capacity due to increased surface area.
6. Increased water-holding capacity from thorough working of the soil.
7. Improved drainage for plants.
8. Slower water runoff and hence greater water absorption because ridges are parallel to the contour.
9. Decreased erosion because ridges are parallel to the contour (p. 20).

Farmers in Geita seem to be particularly concerned about building good ridges. Shapiro noted that some farmers "would hire imigrants from Burundi to (sesa) a field but not to ridge it, because the imigrants do not make ridges in their own country and hence have little skill in the task" (p. 20).

The laborious task of land preparation has its complement in the high level of field care throughout the farming season. Anthony and Uchendu observed that "the standard of traditional cultivation in our area was good and the practice of weeding and splitting ridges provides good weed control in the early stage of crop growth (when it is most critical). Crops were remarkably weed free" (p. 59).

Agricultural Calendar

In Table 3.9 are shown the timing of the various crop operations for various crops grown in Mwanza and Shinyanga regions. However, different survey sources give different calendars of operations depending upon the particular district surveyed, the type of cropping pattern prevalent at the time of the survey, and the variety of crops being grown. For Geita district, Shapiro showed the timing of the various tasks involved in cotton cultivation. The first labor peak is in the second half of November when ridging occupies most of the farmers' time. Most land preparation is completed by mid to late December, after which weeding becomes most important, remaining dominant until the end of April. Harvesting begins in mid-May and reaches a peak in June.

Collinson showed the following peak periods for labor when he considered all the main crops: the November land-preparation peak, the January weeding peak, and the June harvest peak. The first two peaks coincide with the time when a great deal of labor is also devoted to food crops, especially maize. Shapiro noted two important consequences of this labor pattern. "First, the coincidence of labor peaks for cotton and food crops strains the supply of family labor. Almost all outside labor hired in the area is for land preparation and weeding. Second, if cotton were planted one-half month earlier (a common recommendation) the peaks of cotton and food harvesting would coicide and thereby force many farmers to hire outside labor in late April and early May. This would be a third period of labor hiring, because the land preparation and weeding peaks probably would still occur" (p. 25).

Table 3.9

Calendar of Crop Operations for Mwanza and Shinyanga Regions[a]

OPERATION	PLOW	RIDGE	PLANT	WEED 1	WEED 2	1ST HARV.	2ND HARV.	3RD HARV.
FOOD CROP								
Pure Maize or Sorghum-Millet	Jan.	Jan.-Feb.	Feb.-Mar.	Feb.-Mar.	Mar.-Apr.	June	July	-----
Early Legume-Cassava-Maize	Oct.	Oct.	Oct.	Nov.	Nov.-Dec.	Dec.-Jan.	-----	-----
Early Sorghum	Oct.	Oct.	Oct.	Nov.	Nov.-Dec.	Dec.-Jan.	-----	-----
Legumes	Nov.	Dec.	Dec.	Jan.-Feb.	Feb.-Mar.	Apr.	May	-----
Pure Cassava	Dec.	Dec.	Dec.	Jan.-Feb.	-----	Taken as Required		-----
Pure Sweet Potatoes	Nov.	Nov.	Nov.	Dec.	Mar.	Taken as Required		-----
Pure Rice	Nov.[i]	Jan.[ii]	Jan.-Feb.[iii]	Mar.-Apr.	Apr.-May	May	June	-----
Pure Groundnuts	Dec.-Jan.	Dec.-Jan.	Dec.-Jan.	Jan.-Feb.	-----	May-June	July	-----
CASH CROP								
Cotton	Nov.	Dec.	Dec.	Jan.	Feb.-Mar.	May	June-July	July-Aug.

Source: 1. Calendars for early maize, sorghum, millet, legumes, cassava, sweet potatoes and cotton taken from field notes of World Bank Project team in Mwanza and Shinyanga regions.

2. Calendars for rice and maize mixtures from M.P. Collinson's "Farm Management Survey Report No. 4," p.9.

3. Calendar for groundnuts from C.K. Klein, D.A.B. Green, R.L. Donahue, and B.A. Stout, Agricultural Mechanization in Equatorial Africa, p.2.

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[a]This is an acceptable model calendar, with 25 percent of the crops grown one month earlier and 25 percent one month later.

i, ii, and iii refer to seedbed preparation, cultivation and transplanting respectively.

Because of the importance of the sowing date for cotton (often stressed by extension agencies), it is important to further explore the calendar of operations. Reference is made to Table 3.1 above, in which is shown the distribution of rainfall in the district, and to Table 3.10 below, in which is given a theoretical typical growing calendar for cotton in the area.

Without reference to any specific area, Purseglove discussed the ideal rainfall pattern for cotton:

> Adequate, but not excessive moisture is required for early vegetative growth; the first flowering period requires relative dryness, otherwise excessive boll shedding ensues; an increase in moisture is required for boll swelling and reserved growth, followed by dry weather for ripening and harvest. Up to 15 percent more bolls are shed on days when rain falls during flowering (p. 348).

Spence, and Spence and Littledyke did not mention the need for relative dryness during the first flowering period. But they did note that available moisture should increase from germination to peak flowering time when the water requirement is at its highest. This happens 100 to 130 days after sowing.

The dangers of too much, rather than too little, rainfall are often emphasized. A possible reason, as Purseglove noted, is that "wild (cotton) species are xerophytic and the ability to withstand drought has persisted in modern cultivated cottons so that they can recover from a dry spell and resume growth and fruiting" (p. 348). Since Geita is a relatively wet area, this emphasis on excess rainfall is probably warranted. There is some evidence that shows the effects of too much rainfall. For example, during the 1961-62 farming season, there was excessive rainfall with the following results as

Table 3.10

A Typical Growth Calendar For Cotton

In Tanzania's Western Cotton-Growing Area

STAGE	DATE
Planting	December 1
Germination Completed	December 7
Flowering Starts	February 7
Flowering Peaks	March 12
Harvest Starts	April 16
Harvest Peaks	May 11
Harvest Ends	July 20

Source: J.R. Spence, "The Importance of Sowing Date for Cotton," p.1.

reported by the empire Cotton Growing Corporation:

> ...the high rainfall reduced yields in many areas... whereas at Ukiriguru the optimum rainfall from December to March for cotton production is about 455.76 mm, rainfall during this season was 633 mm. Excessive leaching of the soil nitrates may have occurred, and also many reports of rotting of seed and young plants have been received from the district (p. 9).

During the 1967-68 growing season, the Cotton Research Corporation also noted the following:

> The crop harvested in 1968 was the smallest since 1964... largely because of unusually heavy rainfall, particularly at the beginning of the season in November and again in February, March and April, making the year's total 1480 mm, the greatest record in Ukiriguru....
>
> The heavy early rainfall created difficulties in land preparation and sowing; later in the season there were severe leaching in the light-textured soils and waterlogging in the heavy low-lying soils; farmers' weeding problems were increased and the season was favorable for American bollworm (p. 1).

Shapiro summarized the potential effects of excess rainfall as follows:

1. Increased difficulty in land preparation and sowing.
2. Rotting of seeds and young plants.
3. Severe leaching on light soils.
4. Excessive boll shedding in waterlogged heavy soils.
5. Increased weeding problems.
6. Improved environment for pests during the growing season.
7. Damage to exposed cotton fibres.
8. Shortened dry season and hence better survival rates for pests (p. 50).

As mentioned previously, most soils in Geita are light. Thus, leaching is more likely to be a problem than is waterlogging. The ill effects of leaching can be reduced, if not removed, by the application of nitrogenous fertilizer, just as insecticides can combat the higher pest populations resulting from heavy rains. The only problem is that very little fertilizer and insecticide are used in the area as in other areas of the country.

To minimize the effects of excess rainfall, research at Ukiriguru recommended a planting period between November 15 and December 15. This recommended period coincides with the time when a great deal of labor and other resources are devoted to food crops. This relates to the objectives of the study presented in Chapter I.

Pests and Diseases

The most damaging pest in Tanzania is the American bollworm. In the western cotton-growing area (WCGA), spring bollworms and blue bugs are singled out as being among the primary pests. Because Geita District is relatively wet and cool, it has problems with two pests that are not so important in most of the rest of the WCGA. These are Lygus Spp. and Helopeltis Schoutendi. The former pierces the young cotton buds after which they drop off the plant. Thus there is little fruit and less output. The latter injects its toxic saliva into the stem, leaves, and fruit of the plant when it pierces them to feed. The saliva causes browning, scarring, and withering in the affected parts. Both pests can be controlled by the use of DDT or Thoidan.

American bollworms appear in great numbers soon after the plants flower, about ten weeks after sowing. This pest can ruin most of the early cotton crop. The spiny bollworm continues the job started by the American bollworm. It begins by boring into and killing the growing points of the plant. Late in the season it feeds on buds, flowers, and bolls--the attack reaching a peak in June. Although the latter can be greatly reduced by uprooting and burning all cotton plants after harvest (before September 15 in Geita), it is difficult to deal with the former by the same method. Reed (n.d.) argued that farmers can prevent an excessive buildup of American bollworm and might even reduce the population in the cotton fields if maize were planted strategically:

> American bollworm normally builds up on early maize where it feeds on the cob tips and then migrates to the cotton. The growing of early maize next to cotton...(almost ensures) heavy bollworm attacks. Wherever possible, maize should be sown after cotton, for the bollworms may then be attracted away from the cotton to maize, where they do little damage (p.1).

DDT can kill American bollworms only if it is sprayed 6 to 8 times, as recommended. If it is sprayed only once or twice, as is now done by many farmers, the American bollworm population may build up to devastating numbers. The effectiveness of DDT or any other insecticide depends on farmers knowing how to use it; however, the price of DDT or Thiodan relative to output prices is an extremely important factor, of great interest to this study as mentioned in Chapter I.

Recommended Practices

The Ukiriguru research station in conjunction with the extension service in the area have developed a set of general cotton-growing recommendations for the WCGA. The recommendations have been developed with the realization that the WCGA has many different microenvironments, each perhaps requiring a unique set of detailed recommendations. But because of manpower limitations, nothing more than general recommendations could be developed. The following is a simplified list of general recommendations for the WCGA:

Recommendations related to cultivation practices.

1. Plant all cotton between November 15 and December 31.
2. Plant six to ten seeds per hole, 25 millimeters deep and cover firmly.
3. On ridges that are 1.52 meters apart, plant two rows 0.46 meters apart and space the seed holes 0.46 meters apart in in each row.
4. Thin to two plants per stand after three weeks.
5. Weed for the first time while thinning.
6. Weed three to five times during the season to keep the field weed free at all times.
7. Harvest as bolls open and cotton dries; do not allow open bolls to remain on the plant very long.
8. Uproot and burn all cotton plants by September 15.
9. Rotate three years of cotton with three to five years of cassava.

Recommendations related to new inputs.

1. At sesa (land-preparation) time, put double superphosphate in the former furrow of the split old ridge where the new ridge is to be built. Use 125 killograms per hectare.

2. At six weeks apply ammonia sulphate in a shallow ditch between the two rows of plants on top of each ridge. Use 125 kg per hectare.
3. Start to spray Thiodan or DDT when the cotton plants begin to flower, usually at ten weeks. Use half a kilogram of active ingredient (75 percent DDT powder) mixed with 60 litres of water for each acre.
4. Spray Thiodan or DDT six times at two-week intervals.
5. If and when stainers or blue bugs build up, spray with carbaryl.

These recommendations are discussed below under the following headings: planting; thinning and weeding; harvesting; uprooting and burning; rotation; fertilizers; and insecticides.

Planting. The method of land preparation in Geita is quite satisfactory and acceptable to the Ministry of Agriculture and the Tanzania Cotton Authority (TCA). However, the timing of land preparation is crucial if cotton is to be planted between November 15 and December 31. Spence (n.d.) noted that "the most important factor in land preparation is correct timing: (p. 1).

Planting during the recommended period increases the probability that the moisture requirements of cotton will coincide with the rainfall pattern. Since rains usually start in late September, by mid November the land will probably contain enough moisture to insure germination. Maximum water requirement for cotton occurs during peak flowering, which takes place 100 to 130 days after sowing. Since April is the month of greatest rainfall, cotton planted in December probably will be flowering under ideal rain conditions. Since rainfall diminishes rapidly in May, for cotton planted during the recommended time, there is not too great a risk of rain falling on open bolls.

In Geita, unlike the rest of the WCGA, the rainy season extends late; thus cotton should be planted during the later part of the recommended period. If cotton is planted too early, the bolls may open during the rains.

The sowing recommendation of 6 to 10 seeds per hole, when only two plants ultimately are to be left, is based on three considerations. First, 100 percent germination is not expected. Second, seedling mortability is high during the first three weeks of growth. Third, the soils of the WCGA form a crust after rains, and the force of several seedlings is required to penetrate it.

The reommendation that stands of cotton be 0.46 meters apart is less widely adopted. Most farmers believe that this distance is too close. There is no agreement by the farmers as to why this is so. Some say that such close planting leads to much vegetative growth but few bolls. Others say that it encourages greater insect damage. In the high temperatures of unshaded areas, insects may not breed well. Under denser plantings, however, insects may breed faster because of the shade. Spencer (n.d.) noted that farmers seem to choose wider spacing "due to the superior appearance of the plants at wider spacings...(they are) impressed by the high yield per plant given at wider spacings" (p. 6). This can be interpreted as risk avoidance on the part of farmers, since healthy plants may be better able to withstand insect attacks and possible short periods of drought.

Thinning and weeding. Most farmers follow these recommendations. They leave two cotton plants per stand and try to keep their fields weed free. If thinning and first weeding are done simultaneously, the plants will get off to a good start. Although thinning is easily done when the ground is wet, it would not be delayed because of a dry spell since in dry soil the competition of excess plants for water becomes more damaging. Although it is easier and more effective to weed during a dry spell, the timing for weeding like that of thinning, is very important. Weeding should not be postponed until the weather is just right.

Harvesting. The timing of cotton harvesting is very important because fibres in open bolls may be rained on and, hence, turn gray if left on the plant too long. On the other hand, the open bolls should not be picked too soon; a few days are needed for the fresh fibres to dry. Because bolls do not open or dry simultaneously, more than one picking is necessary if all cotton is to be picked at the proper time.

After harvesting, farmers must sort cotton into clean (grade AR) or dirty (grade BR) piles. Grade AR may constitute about 90 percent of the total harvest. This sorting is important because the two grades have different prices.

Uprooting and burning. It is recommended that all cotton plants be uprooted and burned by September 15. Because of the failure of many farmers to follow this recommendation, it has been made a bylaw. Farmers are subject to fines if they have cotton on their fields after the recommended date. The reason for passing a bylaw on this recommendation is that cotton plants left on one farmers' field may serve as hosts for insects that attack a neighbor's field. If all insects are to be eliminated, uprooting and burning must be done by every farmer, and done most carefully.

Crop rotation. Spence (n.d.) noted that an ideal rotation "system has not yet been achieved with cotton in the WCGA and no recommendations can be made on cotton rotations yet" (p. 10). Anthony and Uchendu reported differently for Geita." In Geita it is recommended that unfertilized cotton should be moved every fourth year and alternated with cassava" (p. 35). They based this recommendation on the following considerations:

> Cassava, especially if left unweeded, has been shown to have a beneficial effect on the following cotton crop. In an experiment at Ukiriguru, cotton sown after three years of cassava, both crops without applied fertilizer, gave better yield over a three year period than continuous cotton receiving 45.4 kg of sulphate of ammonia every year and 45.4 kg of double superphosphate every third year (p. 35).

Most farmers in Geita are aware that the cassava-cotton rotation is a good practice. However, intercropping and crop rotation practices have been less and less applied during the last ten years. In an attempt to provide close supervision of cotton and maize production, the government allocates and regulates the use of land. Block farms have been established in which only cotton and maize can be grown. Other crops such as cassava, legumes, and vegetables can be grown on land allocated around homesteads.

Fertilizers. The recommendation on fertilizer application is quite general and does not take into account local conditions of different areas within the WCGA that may lead to extreme variability in responses to fertilizer. Shapiro reported that Geita district differs in two important ways from most of the rest of the WCGA. The district receives more rainfall than the rest of the WCGA. Second, its soil was not tapped to any great extent, until after World War II, whereas most of the rest of the WCGA was under cotton cultivation since the early part of the century.

Fertilizer responsiveness in Geita, therefore, has been quite different from that in other areas. In general, the response to superphosphate in Geita has been low relative to the response elsewhere, whereas the response to ammonium sulphate may be relatively high. LeMare (1967) in summarizing the Ukiriguru field trials, had this to offer:

> Yield increases due to superphosphate have been confined to the area of Sukumaland which has been under cultivation for a long time. This comprises the districts of Mwanza, Kwimba, Maswa and Shinyanga. Elsewhere (for example, in Geita) responses to phosphate have been small....
>
> The pattern of nitrogen (for example ammonium sulphate) response is more difficult to summarize because, unlike phosphate, its effect is more variable between seasons, and depends more upon the amount of water available.... Where ample water is available, and where other soil factors are not limiting (conditions more common in Geita than elsewhere in the WCGA), nitrogen can have a very large effect on yield and can be profitable up to very large dressings (p. 3).

It should be remembered also that the benefits of fertilizer will vary, in part, according to the extent of insect damage. As LeMare (1967, p. 3) put it: "the effect of fertilizer may be almost completely lost if the crop is subject to severe insect attack."

Insecticides. Shapiro reported that many farmers and agricultural officials believe that insecticides alone produce greater benefits than do fertilizers alone. This observation is substantiated in Table 3.11.

Table 3.11

Responses to Nitrogenous-Fertilizer Under Varying Insecticide Applications[a]

Insecticide Spraying Regime	Nitrochalk Applications 0	(kg/hectare) 200
None	419	424
Standard	1076	1173
Best	1515	1880

Source: P.H. LeMare, "The Importance of Insect Control for Fertilizer Responses in Cotton," p.2.

[a]The experimental plots were in the Mwanhala area.

The insecticide recommendation is probably more important in Geita for two reasons. Recent settlement implies more remaining natural soil fertility, whereas greater rainfall means that many pests may be more damaging in unsprayed fields. However, the conditions attached to this recommendation have somewhat impeded its adoption. The recommendation calls for heavy labor inputs. To spray one hectare, the farmer would need sixty litres of water to be mixed with DDT powder. Not only that, but the process of spraying has to be done every two weeks for a total of six times during the season. Not many farmers can readily get water near their farms. And even if they catch and store rain water, they would be unwilling to use this valuable clean water for spraying. Fetching water from streams is too laborious for them.

In the last five years or so, farmers have been introduced to two other insecticides, namely Thiodan and Cidial. Pumps are used for spraying. But the pumps require batteries, which are sometimes unavailable in the market or are very expensive when they are available. Thiodan and Cidial are extremely poisonous to human beings. Incidents of people who have lost their lives after ingesting either of these insecticides are known all over the district. This has impeded the adoption of the recommendation.

Recommended Practices for Maize

In contrast to cotton, little research has been done on maize production. The research station at Ukiriguru and many others in the country have been researching export crops such as cotton, coffee, tobacco, and tea. Only since the mid 1970's has there been research interest in food crops, particularly in maize. The reasons for this interest were presented in Chapter II. Thus, there is no detailed and comprehensive list of recommended practices for maize. However, research at Ukiriguru has provided some general recommendations that are subject to further research.

Recommendations related to cultivation practices.

1. Plant maize between November and December.
2. Plant two to three seeds per hole and cover firmly.
3. On ridges that are 0.9 meters apart, plant one row and space the seed holes 0.3 meters apart.

4. Thin to one or two plants per stand after three weeks.
5. Weed for first time while thinning.
6. Weed two to three times during the season to keep the field weed free at most times.
7. Harvest when the grains are dry enough to be milled into flour.
8. Uproot and burn all plants before next season.

Recommendations related to new inputs.

1. During planting, add about 50 kg of TSP per hectare.
2. Apply sulphate of ammonia three times during the season, the first application should take place when the plant is about 21 centimeters high, the second when the plant has reached the level of the knee, and the last during tassling.
3. Start to spray with DDT when the plant is about six weeks along; spray three to four times at two-week intervals.

In addition, it is recommended that farmers use better seeds (mostly hybrid seeds) instead of composite seeds, which are commonly used in the area.

The absence of any field evidence has led to a conclusion (based on observations) that unlike cotton, maize is not as critically affected by insects or weather. Farmers, however, consider weather, especially rainfall, as being crucial to maize production. In particular, they are afraid of a shorter rainy season that occurs in the area every few years. To avoid any risk, farmers plant maize as soon as the rains start. That is the time when cotton should also be planted. And, as discussed in Chapter II, this creates labor-allocation problems for farmers, as do the recommendations for weeding and harvesting.

The recommendations for fertilizer and insecticide application also create a problem for making capital allocation between cotton and maize. This and the labor-allocation problems mentioned above are aggravated by the fact that cotton and maize can be grown on the same soils. Because cotton requires more resources and higher management skills than maize, more variability in yields have been experienced by farmers in the study area.[3]

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[3]Ninety-seven percent of the farmers in the sample experienced more variability in cotton yields than in maize yields during the last five years. Through informal discussions with extension agents in the area the researcher found the farmers' response to the question was true.

CHAPTER IV

THE ANALYTICAL FRAMEWORK OF THE STUDY AND RESEARCH METHODOLOGY

The Analytical Framework

The choice of an analytical technique in constructing a model depends upon the availability of data, the purpose for which the model is intended, and the nature of the structural coefficients being sought to elucidate a particular problem. In this study, linear programming was used in the analysis of the data.

The use of LP as the computational tool in the farm-planning exercise was based on the premise that small-holder farmers tend to behave in ways that optimize their objectives given the constraints within which they operate. Production and consumption considerations are both important for small-holder farmers. Consequently, an attempt was made to integrate the two decisions into a single methodological framework. Endogenous determination of consumption activities in LP permitted the premise that staple food is grown for home consumption and/or for sale in the market.

Risk factors are an important consideration in small-holder decision making. Therefore, some method of incorporating risk factors into the LP framework was needed. A number of approaches have been developed to take into account risk factors in LP models (Kennedy and Francisco; Andrews and John; and McCarl), but there is yet no clear guidance for choosing the most appropriate method. Not only that, but time-series data on yields, prices and production costs that are needed to measure income variability may not be available. Data are required for the application of quadratic-programming techniques to small-holder farm behavior under uncertainty.

It is more likely that small-holder farmers are concerned about achieving a minimum level of production with certainty rather than minimizing income variance. In this study, risk factors were incorporated in the analysis only as consumption constraints for the major food crop.

The Use of the Linear-Programming Technique for Analyzing Small Farm Agriculture

The linear-programming technique has been applied increasingly in recent years to solving small-holder problems in Africa and other third-world countries. In his study of resource allocation among subsistence farmers in Ghana to evaluate various policy recommendations designed to increase agricultural production, Atta Kouadu employed the LP technique. Thamrin Nurdin examined factors affecting farm decision making of small farmers in west Sumatra by lexico-graphic programming in order to cope with multi-objectives behavior. Ogunfowora, using Nigerian data, undertook an analysis of the constraint posed by periodic specific capital shortages and by quality of management as well as by labor. Subjective limitations reflecting management differences and risk-aversion behavior distinguish two farm models that represent different levels of commercialization. Shadow prices for labor and capital suggest the types of government policies that most efficiently increase income potential in these respective farm types.

Ogunfowora also used a poly-period dynamic-programming model to plan operations for a farm settlement scheme that would assure both an adequate income and short-period repayment capability. Norman used the LP techniques to evaluate the profitability of agricultural production and labor utilization among the Hausa of northern Nigeria.

Specifically, he used the technique to assess the profitability of several adjustments in farm models based on data from the area. These adjustments included reallocation of existing resources, increasing the input of labor on a year-round basis, introducing currently available new technologies for groundnuts, sorghum, and cotton, and increasing prices of crops purchased by the marketing board. The adjustments tended to increase farm income.

Heyer (1971) discussed several broader macro uses to which linear programming micro analysis can be put, including the shadow pricing of agricultural resources, the assessment of employment and mechanization programs, and the evaluation of new variety profitability and research priorities. Using data collected in Kenya, Heyer described as valid the changing pattern of constraints that limit output under such alternative mixtures as the land-labor ratio. Nonfarm allocations of labor time were not incorporated in the model. The analysis was extended, however, to include uncertainty restrictions.

Norman and Ogunfowora used LP techniques to assess profitability of adjustment as well as to estimate specifically farm-firm fertilizer demand and its elasticities with respect to own price, product price, and capital, making it useful for policy prescription. The study also showed that the linear programming technique can be used to estimate resource demand in an environment lacking time-series data.

The Linear-Programming Model

Linear programming is a technique for maximizing (or minimizing) a linear-objective-function subject to some linear constraints. The model has three components: (1) the objective function; (2) resource constraints; and (3) activities. According to Heady and Candler, the mathematical formulation in matrix form is given as follows:

Maximize $Z = c'x$

subject to:

$AX \leq B$

$X \geq 0$

where:

Z = the objective function to be maximized (or minimized)

C = n x 1 vector of prices

X = n x 1 vector of activity levels

A = m x n matrix of input-output coefficients

B = m x 1 vector of resource restrictions

In order to obtain a determinate solution, several assumptions are made: (1) additivity and linearity of activities; (2) divisibility of activities and resources; (3) finiteness of alternative activities and resource restrictions; and (4) single-value expectations; i.e., resource supplies, input coefficients, and prices are known with certainty.

The main advantage of this LP model is that it "...allows for several farm commodities as farm activities, seasonal labor and land constraints, more than one production technique, land-labor-capital substitution and a choice among several farm activities which are subject to different economic resource and behavioral constraints" (Mudahar, p.2). Thus, unlike other commonly used calculation techniques of farm planning, linear programming can be used to provide a more adequate analytical description of whole-farm situations.

An equally important advantage is that LP allows the determination of certain important economic measures of the optimal plan. One can say, for example, how stable the optimal plan is, measured in terms of the change in the net revenue of each enterprise needed to bring about a change in the levels of the activities in the optimal solution. Similarly, the productivity of the farm resources can be assessed and the importance of the various planning constraints evaluated.

The technique, however, has a number of limitations. First, the standard LP model does not include any allowance for risk, which is central to decision making among small-holder farmers. (New methods such as MOTAD allow for handling risk.) The importance small farmers attach to securing an adequate food supply as a primary objective is well documented (Collinson, 1964; Heyer, 1969). Because of unreliable marketing organizations, the wide gap between buying and selling for identical or readily substitutable foods and the year-to-year variation in prices and crop yields that accentuate the risk aversion, even farms with well-developed markets continue to produce all or most of their subsistence requirements. Thus, the objective function for small farmers may indeed be security maximization rather than cash-income maximization (Norman).

Another limitation of the LP technique results from the assumption that the farmer will adopt any enterprise combination as long as it promises the highest income. This may not be the case. Often certain crops and livestock weigh more heavily than others in the preference of farmers. Heyer (1971) contended that the objective function is difficult to determine under small-holder farming because it is ambiguous, and risk considerations tend to dominate production decisions. Further, cultural and institutional factors constrain the production environment. However, the standard LP model outlined above can be modified to include allowance for risk and to estimate product supply as well as resource demand. The modified standard LP model is called the parametric-programming model. It enables the researcher to study the effects of a wide range of costs or prices on the optimum solution to the standard simplex method. Such a linear-programming problem with parametric objective functions has been conceptualized as follows (Ogunfowora; Mwangi):

$$\text{Maximize } Z_\alpha = \sum_{j=1}^{n} C_j X_j$$

subject to:

$$\sum_{i=1}^{m} aijXm \leq b_k$$

and

$$X_j \geq 0$$

where:

$$Z = z(X_1, X_2, X_3 \ldots . X_j, \ldots . X_n)$$

$$C'_j \leq C_j \leq C''_j$$

$$\frac{C''_j - C'_j}{X} = k \text{ or } C''_j - C'_j = k$$

Z = the α^{th} objective function to be maximized for a given price level within the acceptable price range and for a given technology.

b_i = the level of the i^{th} resource available.

C'_j and C''_j = the lower and upper limits of the j^{th} activity.

k = the number of optimum solutions within the price.

X = constant increments in the price of the j^{th} activity.

The farms are assumed to have achieved an optimum organization before price and technology change occurs.

Even the modified LP model has not gone unchallenged. In a comment on planned versus actual farmer performance under uncertainty in under-developed agriculture, Palmer-Jones criticized the method employed by Heyer (1972) to analyze small-farmer behavior. Palmer-Jones questioned the legitimacy of using average input-output coefficients in the LP models used for the analyses because, first, farmers may in fact alter their strategies or technical inputs under different environmental conditions, and second, there is no theoretical reason to believe that average inputs will give rise to average outputs. But Palmer-Jones did not stop there. He went on to question the use and validity of the LP techniques for studying small-farm situations in general. The main argument Palmer-Jones gave for this criticism dealt with data problems.

Although Low (1978) agreed to the criticism directed at the Heyer analysis of peasant-farmer behavior under uncertainty, he disagreed with the criticism that the LP technique cannot contribute anything useful in the study of peasant-farming situations. He supported his disagreement by quoting two examples from his own work. First, an unexpected relationship observed in southeast Ghana between the introduction of tractors that enabled the expansion of cassava to the savanna lands and the expansion of forest-cultivated maize for which tractors were not used, were explained in terms of an LP specification (Low, 1974).

The explanation involving subsistence requirements, a third activity, resource allocations between the three activities, and a maximum uncertainty specification could not have easily been worked out in the absence of the LP technique.

A related paper (Low, 1975) examined the implications of the LP model for extension strategy. The conclusion reached in respect to an improved maize recommendation, for example, seemed to explain, contrary to what was expected on the basis of a partial-budget model, why the innovation had not been readily adopted by certain farmers. Because the model accounted for such factors as uncertainty, product-product relationship, the allocation of clearing labor to a succession of crops, and the relationship between production and consumption, including the effects of storage losses and seasonal price fluctuations, it probably constituted a more realistic representation of the peasant-farmer decision-making environment than the partial budget model.

Linear programming was used in the present study for the following reasons:

1. In LP, a large number of interrelated variables can be handled, and thus family-farm systems can be studied that are characterized by a high degree of interdependence between production and consumption, consumption and investment, investment and resource availability and social and cultural constraints as mentioned at the beginning of this chapter and in Chapter V below.

2. The maximum possible profit for a farm-planning problem is guaranteed. This is difficult, if not impossible, to obtain with

ordinary budgeting for any complex problem.

3. With LP it is easy to vary available prices and resources as well as input coefficients in order to simulate various management levels. LP makes it possible to look almost instantaneously at a range of possibilities, ones so laborious to determine with ordinary budgeting that such possibilities could not be examined in practice.

In short, LP seemed to be the best technique for attaining the objectives of this study as set forth in Chapter I.

Research Methodology

Choosing the Research Site

The choice of the research site was determined by two primary reasons. First, it had to be an important area for cotton and maize crops. The purpose for doing a micro-survey on cotton and maize was broadly justified in Chapter I. That justification can be summarized as follows:

1. Cotton accounts for more than 17 percent of the country's total exports, which in turn make up for about 30 percent of the country's GDP. Thus, it is an important source of foreign exchange, which is badly needed to pay for the country's import requirements. And, as was shown in Table 1.4, Geita is the most important cotton-producing area.

2. Maize, on the other hand, is the main food crop in the country, especially in the cotton-growing areas and more so in Geita. For the past few years, Tanzania has not been able to meet her domestic needs for this crop and has had to spend much of her foreign reserves to import maize. Increased production of maize would thus reduce food imports.

3. The improvements in the production of both crops in Geita are financed by the World Bank and involve many small farmers.

4. Both crops are grown primarily by small farmers under the following conditions.

   a. Neither crop is irrigated; hence they are subject to particular erratic weather conditions;

   b. Both crops use farming methods that are extremely time consuming; and

   c. Both crops are grown during the same season and are thus competitive for labor and other inputs.

The second reason influencing the choice of the research site was that the area had to have been the subject of enough prior research so that adequate background information could be acquired before the researcher went to the field. Malcolm, Anthony and Uchendu, and Collinson (1964) among others provided basic agricultural information about Geita.

Choosing the Sample

The population of the study consisted of all family farms in the main cotton- and maize-growing villages in Geita district. For the purpose of this research, the population of the study was not confined to those villages in the World Bank's cotton project.

Procedures for Selecting Respondents

In order to increase the representativeness and precision of the sample, the population was divided into two strata. One stratum consisted of participants and the other of nonparticipants in the World

Bank's cotton project. This stratification was justified by the objectives of this study. The two strata were believed to be different in terms of the source, type, and extent of resource constraints imposed on their decision-making process. This belief was justified by the assumption that the participants used the full package (fertilizer, better seeds, insecticides, and so on) whereas the nonparticipants did not; this assumption was not empirically tested).

The list of villages under each stratum was provided by the evaluation unit of the Geita cotton project. During the same farming season, the evaluation unit conducted farm-managment research.

The sample in the study consisted of 286 farmers involved in the cotton project and 215 farmers not in the project. The unit had well-trained enumerators with two to three years of experience in data collection. It also had an easy access to the project's transport system. The unit was short of supervisors, so the researcher was considered very useful. In exchange for the researcher's supervision, the unit allowed the researcher to use its enumerators. In order to minimize the work of the enumerators, the researcher's sample was selected from that of the unit as long as the objectives of the research were not compromised. The happy coincidence of the unit's and the researcher's interests facilitated a smooth cooperation between the two.

As a result of its previous research experience in the project, the unit was able to provide adequate information about which villages used plows; it also had a list of farmers who had already applied to the project for tractor-hire services. This information was important and necessary for the selection of the sample.

Sample Size

Ideally the sample size should be determined by the degree of precision required (Yang). Statistical theory is most useful in helping determine the size of the sample only when one variable is handled and its variance is known in advance. However, more than one variable was dealt with in this study; the variables used here included such factors as family labor, hired labor, animal power owned and hired, tractor services, prices received for crops sold, and wage rates. It was thus impossible to apply a formal statistical procedure that would achieve a statistical representativeness of the sample.

Another problem that hindered the use of a statistical procedure for selecting the sample size was the cost that would be involved especially in hiring enumerators and processing the data. In selecting the sample for this study, therefore, much consideration was given to cost, time, availability and experience of enumerators, and last, but not least, some degree of precision. As a trade-off between cost minimization and precision, a sample of 80 households (40 from each stratum) was considered to be sufficient.

The primary sampling unit was the family-farm household. The family household represented both the production unit and the consumption unit from each village. Enumerators, with the help of village leaders, prepared four lists: the first list consisted of those households that had decided to use labor (of any kind) for every farming operation; the second consisted of those households that owned plows and intended to use them in some farming operations; the third consisted of those households that intended to hire plows for some operations; and the last list contained those households that intended to hire tractor services. The last list had already been prepared by the evaluation unit of the Geita cotton project.

The main purpose of preparing these lists was to insure that the sample included these different farming systems. Not many farm households owned plows; therefore, all households that owned plows were included in the sample. From the list of households that had decided to hire tractor services, a random sample of 10 households was drawn. This was done for both participating and nonparticipating farm households. Yang suggested at least 20 farm households as being necessary for reliable estimates for each stratum. Friedrich concluded that roughly 20 to 25 observations should be included in each stratum in order to make a reliable comparison. However, the reliability of estimates very much depended on the actual variability of the population. From each stratum, 4 substrata were constructed. The first was a substratum of farm households using only labor for farming operations; the second was for those family farms using owned oxen plows; the third was for those using hired ox plows; and the fourth was a substratum of family farms that hired tractor services. Each substratum was expected to provide 10 observations. Lack of observations (especially for ox plows), however, resulted in different numbers of observations. From the list of farm households using only labor for farming operations, random samples of 21 and 22 farm households were selected for participants and nonparticipants respectively. The main difference between the two samples resulted from the difference in the application of ox plows.

Among the participants, only 5 owned plows and only 4 were ready to hire ox plows. Among the nonparticipants, only 2 owned plows; only 6 were ready to hire them.

Replacement

Some investigators mentioned the problem of uncooperative farmers. This problem was expected in this study because of the political sensitivity of the cotton-maize projects. To guard against such an eventuality, the possibility of the nonresponse rate was assumed to be 10 percent for each stratum, thus increasing the target sample for each sample by 10 farm households using only labor. To guard against noncooperation from plow owners and from those who intended to hire either tractor or plow services, much depended on the cooperation of village leaders and enumerators. Although enumerators were expected to be cooperative and friendly to all selected farm households, they were instructed to work more closely with those farm households owning ox plows and hiring plows or tractor services. This measure was taken to avoid losing any observation from these groups whose number was limited. The outcome was extremely favorable.

From those farm households selected for their use of labor in every farm operation, only four dropped out (one because of death in the family, two because of family quarrels, and one because of misunderstanding with village leadership). None dropped out from those who owned plows or from those who intended to hire tractor services, one household changed its mind about hiring the services. Since there was no other farm household in this category in the selected villages to replace this farm, the household was left in the sample as one that used only labor for all farm operations.

The good cooperation that the study received from the selected farm households and village leaders can be explained. First, the enumerators were well known by villages; they had been in the area for the previous three years. Second, most of the enumerators knew the local language; thus they were not suspected of anything covert. They were trusted.

Data Collection

The researcher designed and developed questionnaires for the purpose of collecting the needed data. This included data on the production, prices of inputs and outputs, and the resources that were available or could be available on the farm. Data for only one cropping season, 1979-80, were collected.

The data were collected by six enumerators who were well trained by the evaluation unit of the Geita cotton project. Enumerators visited each farm household twice a week for a full year. For each household member, the enumerators recorded all the activities done and for how long prior to the interview. More emphasis was given to the collection of data on labor use, and family-labor allocation during the peak demand for labor (especially during weeding). This format of twice-a-week visits allowed for relatively short recall on the part of respondents. The enumerators were supervised by the researcher.

Input prices as well as output prices are determined by the government prior to the farming season. So these were known by each farm household, and all farmers had given the same response to questions related to prices. However, the researcher observed that most farmers did not sell maize through the established government agency, the National Milling Corporation. Maize is sold on the black market where prices may rise as high as 250 percent above the government price. In fact, most farmers would wait a little longer after harvest to sell their maize output. When asked what would be a fair price for a kilogram of maize, most farmers responded Tshs 2.50, which in fact was a black market price two to three months following harvest.

Construction of the Representative Farms

One method of analyzing the data collected would have been to program every farm household using a case-study approach. However, such an approach would not only have been too costly and, therefore, prohibitive, but also might not have led to meaningful results. Consequently, in carrying out the linear-programming analysis, it was essential to set up a representative farm.

In areas in which there is a reasonable homogeneity with respect to major resources (particularly natural resources such as soil type, topography, and climate) and cultural practices, LP can be used to obtain a representative farm in order to guide planning for individual farms. The manner by which the representative farm is constructed limits its usefulness. Collinson (1974) (p. 125) discussed three alternative techniques for deriving representative farms. They are

1. The identification of a particular farm as the typical farm.

2. The use of an average farm (derived from average resource, input-output, and net price coefficients of a sample farm) as a representative farm.

3. A hypothetical or synthesis-of-composit farm from different components of the population.

It is not easy to find a typical farm. It not only requires the consideration of a wide range of criteria but also the selection and the construction of the criteria are difficult tasks; data for this purpose may not be available nor easy to collect.

The average-farm approach brings with it the aggregation bias. Buckwell and Hazel, Carter, and Miller discussed the agregation bias inherent in the average-farm approach. Aggregation bias exists when the sum of the solution from the individual farms in the set does not equal the estimate obtained by the optimum solution to the entire set directly.

Although the hypothetical farm approach reduces the aggregation bias, it has a practical weakness in that it is difficult to identify several institutional variables and human factors and their distribution within the population. These nontypical variables involve such factors as institutional constraints, motivations, preferences, and managerial ability that have an important impact on farm organization, production efficiency, and earning (Plaxico and Tweeten).

The choice of the method for construction of the representative farm depends on the purpose for which the result of the study is to be used. In this study, the objective was to identify resource constraints and farm adjustments (both for participants and nonparticipants in the Geita cotton project) and to estimate the degree of farmers' responses to input and output price changes. The use of the average farm as a representative farm was justified and was preferred for this study.

The farms in the sample were classified into two groups: the participants and the nonparticipants in the Geita cotton project. The farms in each group were assumed to be sufficiently homogeneous with respect to the key variables that affect farm adjustment. For the analysis, only one average farm was used for each group; this offered an opportunity for more detailed analysis using parametric techniques.

Characteristics of Farms in the Sample

Land Use

The average size of holdings for cotton and maize in the study area was 3.25 hectares for the participants and 2.63 hectares for the nonparticipants. The cultivated areas were 2.52 and 2.63 hectares respectively. Land is allocated by local government officials. About 85 percent of the land allocated is under block farming. Since renting of land is forbidden by law, farmers can only expand their holdings through official land allocation. Land allocated to cotton and maize are located 1 to 2 kilometers from homesteads. This distance has discouraged farmers from using animal manure which has to be carried manually from homesteads where it is kept. Farmers also grow other minor food crops such as cassava, sweet potatoes, and legumes; these are grown around or near homesteads. The average size of holdings for such crops was 0.6 hectares in each group.

Farm-Labor Force

The major source of farm labor in these farms was the family; this was expected because family farms predominate in the study area consisted of 7.7 persons in the participating families and 6.5 persons in the nonparticipating families. The composition of the average farm family in each group is shown in Table 4.1.

Table 4.1

Composition of the Average Family in the Study Area

FAMILY MEMBERS	CONVERSION FACTOR TO MAN EQUIVALENT	NO. IN FAMILY		ACTIVE & DEPENDENT MEMBERS AS % OF TOT.	
		P[a]	NP[b]	P	NP
Head of the Family (Male)	1.00	1	1		
Number of Wives	0.75	1.3	1.2		
Children:					
Male (15 yrs. or more)	1.00	1.6	1.2	88.29	89.23
Female (15 yrs. or more)	0.75	2.1	1.9		
Male & Female (7-14 yrs.)	0.50	0.8	0.5		
Children (younger than 7 yrs.)	0.00	0.5	0.4	11.71	10.77
Dependent Adults (over 60 yrs.)	0.00	0.4	0.3		
Total		7.7	6.5	100.00	100.0

Source: Compiled from the survey data.

[a] Participating families

[b] Nonparticipating families

Family labor is usually supplemented by hired labor or labor acquired through working parties. This is especially true during peak labor demands. Hired labor is paid in cash, whereas labor from working parties is paid in kind (food and beer). The allocation of monthly labor inputs on the representative farm is shown in Table 4.2.

The total labor input on the representative farms was 3948.70 man hours for the participants and 4374.86 man hours for the nonparticipants. 72.02 percent of the participants' total labor input came from the family, 7.55 percent from hired labor, and 20.43 percent from working parties. The sources of labor input for the nonparticipants was remarkably different. 95.82 percent came from the family, 1.55 percent from hired labor and 2.63 percent from working parties.

As is shown in Table 4.2, participating farmers used more hired labor and working parties than did nonparticipating farmers. The main reason for this was that the former group followed crop-husbandry recommendations including three to four weeding operations.

Farm Capital

Farm capital refers to manmade goods or assets that are produced for the purpose of being used in the process of agricultural production. It includes items such as machines, tools, buildings, livestock, seeds, fertilizers, and insecticides. Such assets are usually classified, according to the length of their productive lives, into fixed- or long-term capital and operating- or short-term capital. The former consists of items such as machines, tools, land improvements, and buildings with productive lives that extend beyond one production cycle[1], whereas the

[1]Production cycle in this study refers to (1) clearing and cultivation of land; (2) sowing and fertilizing; (3) weeding; and (4) harvesting.

Table 4.2

Total Labor Inputs by Month, Wage Rates, and Payments in Kind on the Representative Farms

MONTH	FAMILY LABOR (Manhours)		HIRED LABOR (Manhours)		WORKING PARTY (Manhours)		TOTAL LABOR (Manhours)		WAGE RATE (Tshs/Hr.)		PAY. IN KIND (Tshs/Hr.)	
	P[a]	NP[b]	P	NP	P	NP	P	NP	P	NP	P	NP
Aug.	74.00	63.00	-	-	-		74.00	63.00	-	-	-	-
Sept.	162.22	268.89	-	-	-		162.22	268.89	-	-	-	-
Oct.	321.98	505.08	28.00	-	139.33	19.84	489.31	524.92	3.10	-	0.69	0.88
Nov.	238.61	487.28	24.50	16.45	106.32	10.25	369.43	513.98	3.25	3.25	0.84	0.63
Dec.	277.78	489.51	85.00	-	124.85	14.51	487.63	504.02	3.87	-	1.05	0.95
Jan.	381.80	506.69	52.00	20.52	128.59	12.39	562.39	539.60	4.13	4.13	0.70	0.76
Feb.	385.36	525.09	60.75	31.03	120.18	23.15	566.29	579.27	4.98	4.98	1.12	1.04
Mar.	169.76	145.17	-	-	-	-	169.76	145.17	-	-	-	-
Apr.	281.18	476.89	-	-	53.40	14.12	334.58	481.01	-	-	1.07	1.27
May	332.64	511.34	47.75	-	86.33	-	466.72	511.34	1.55	-	-	-
June	218.37	213.22	-	-	48.00	20.00	266.37	233.22	-	-	-	0.90
Total	2,843.70	4,192.16	298.00	68.00	807.00	114.70	3,948.70	4,374.86				
%	72.02	95.82	7.55	1.55	20.43	2.63	100.00	100.00				

[a]Participating Families.

[b]Nonparticipating Families.

latter is made up of assets such as fertilizer and seed that are used up in a single production cycle (Upton, p. 149; Herbst, p. 8; Barnard and Nix, p. 50).

The level of fixed capital in the study area was quite low compared to labor. Use of capital equipment to substitute for labor was very small. Each family farm had an average of four hand hoes, two axes, and three chopping knives. Ox plows and tractors were used minimally. Among the participating farm households in the selected villages, only four owned ox plow teams and only four hired animal power. As for the nonparticipants, only two owned ox plow teams and only six hired ox plows. There was no farmer who owned a tractor in either group. However, 25 percent of the farmers in each group hired tractor services for land cultivation.

Livestock is quite important in the study area. Livestock includes cattle, goats, and sheep. Although the Sukuma (the main tribe in Geita) are traditionally cattle-owning people, they are essentially agriculturalists. Cattle ownership fills two important roles: one is economic, and the other is social. Cattle provide a means of storing wealth, and they are sold to provide cash for hiring labor, for fertilizers, insecticides or for any emergency need. Farmers regard investment in livestock as an important contribution to the security of family members. The average number of livestock per family in the study area consisted of 8 cattle, 3 goats, and 1 sheep for the participants and 11 cattle, 5 goats, and 2 sheep for the nonparticipants.

Operating capital is required to purchase farm inputs, such as fertilizer and insecticides, and to pay for hired labor and working parties.[2] The main source of capital in the area is personal savings, which are generally low due to low incomes. Money lenders as a source of credit are nonexistent because the government has banned them; they are considered to be exploiters since they make profit for doing little or no work. Individual family farms cannot take advantage of the little institutional credit (offered by the TRDB or National Bank of Commerce) since such credit can only be given to communal or Ujamaa farms. However, the government, in collaboration with the World Bank, provides input price subsidies, especially for fertilizers and insecticides.

The average value of operating capital for each group in the study area is shown in Table 4.3. It is clear from the table that participating farmers had more operating capital than the nonparticipating group.

Cropping Patterns

The crops grown in the study area can be divided into two groups: those crops grown in block farms and those grown near or around homesteads. Cotton and maize fall into the first group, whereas crops such as cassava, sweet potatoes, groundnuts, beans, and peas as well as garden crops such as cabbages and tomatoes fall into the second group.

Most crops in the second group are intercropped. The most common mixtures are cassava with legumes and/or sweet potatoes. Physical and socioeconomic considerations interact to determine the types of crops

[2]Payment for working parties does not involve cash expenditures. Labor of this kind is paid in kind, a payment that includes food and/or beer.

Table 4.3

Operating Capital of the Representative Farms by Months

MONTH	OPERATING CAPITAL[a]	
	P[b]	NP[c]
August	0	0
September	0	0
October	420.30	275.00
November	317.75	120.85
December	223.00	80.20
January	159.05	100.65
February	172.40	95.00
March	0	0
April	61.45	60.50
May	82.20	0
June	116.00	124.15
Total	1,552.15	856.35

[a] Operating capital given in Tanzanian shillings; it includes cash expenditures and payments in kind; the latter was converted into monetary terms.

[b] Participating Families.

[c] Nonparticipating Families.

and mixtures to be grown. Among the physical factors are rainfall, soil, and temperature. The socioeconomic factors include the need to maximize returns to the limiting factors--especially land and labor; the need to obtain higher output; and the need for security. The last factor indicates that mixed cropping, used as a means of increasing returns to land, is also used as a form of crop diversification, which is a strategy against risk. Such crops, however, are not the direct concern of the government. Most investments by the government and/or the World Bank are geared to improving cotton and maize production in block farms. It is also important to note here that there is no apparent serious competition for resources between cotton and maize on the one hand and cassava, beans, sweet potatoes, groundnuts, vegetables, and so forth on the other.

CHAPTER V

THE STRUCTURE OF THE LINEAR-PROGRAMMING MODELS FOR THE STUDY AREA

In Chapter IV, the mathematical framework for the linear-programming models used in this study was presented. In this chapter, the linear-programming models are described, each having the following elements: (1) an objective function; (2) an activity set; and (3) a constraint structure.

The Objective Function

Small farmers often entertain a number of objectives (including income maximization, output maximization, security and cost minimization) that are not necessarily mutually exclusive. A number of studies (Schultz, Wolf and DeWilde) showed that a variety of objectives exist among small farmers.

In this study, the objective function maximized the net farm income on fixed factors subject to the satisfaction of household food consumption. Every farm household studied gave first priority to the provision of food to its members. This objective function has been referred to as security and profit maximization (Norman). Net farm income was defined as the total value of production less variable costs of production.

There are two alternative approaches to incorporating more than one objective in a single linear-programming model (Upton). One approach is to combine the various objectives into a single-decision criterion such as expected utility maximization. The other approach (popularly known as the lexicographic approach or multigoal programming)

is to employ a hierarchy of objectives, all but one being treated as constraints. The second approach has been used in quite a number of studies on African farmers such as those by Ogunfowora, Low (1974), and Mwangi. It is this approach that was used in this study.

The security objective of producing staple food for the family was specified in the matrix as a constraint to force the production of necessary amounts of maize for meeting the minimum family-consumption level.

Activities in the Model

There were eleven groups of activities included in the model. They were as follows:

1. Crop-production activities
2. Labor-hiring activities
3. Working-party activities
4. Animal-power (ox) hiring activities
5. Animal-power (ox) owning activities
6. Tractor-hiring activities
7. Fertilizer and insecticide-buying activities
8. Crop-consumption activities
9. Crop-selling activities
10. Animal-power selling activities
11. Transfer activities

Crop-Production Activities

In columns A_1, A_2, and A_3 of Table 5.1 are outlined in the crop-production activities for the representative farms in the model. There are two main crops: cotton, which is grown solely for the market and

Table 5.1

Crop Production Activities

ROW	OBJECTIVE Fn. (Cj) / RESOURCES	UNITS	A_1 (Early) CTN	A_2 MZE	A_3 (Late) CTN	SIGN	R.H.S.
			0	0	0		
1	Land	Ha	1	1	1	$\leq$	3.25
2	FL Aug.	Hrs.	74.00			$\leq$	368
3	FL Sept.	Hrs.	78.67	103.55	74.00	$\leq$	377
4	FL Oct.	Hrs.	145.36	176.62	78.67	$\leq$	449
5	FL Nov.	Hrs.	133.55	105.06	145.36	$\leq$	426
6	FL Dec.	Hrs.	153.09	124.69	133.55	$\leq$	433
7	FL Jan.	Hrs.	221.33	160.47	153.09	$\leq$	444
8	FL Feb.	Hrs.	220.75	164.61	221.33	$\leq$	476
9	FL Mar.	Hrs.	169.76	-	220.75	$\leq$	382
10	FL Apr.	Hrs.	124.96	156.22	169.76	$\leq$	402
11	FL May	Hrs.	148.18	184.46	124.96	$\leq$	418
12	FL June	Hrs.	218.37	-	148.18	$\leq$	431
13	FL July	Hrs.	-	-	218.37	$\leq$	483
28[a]	Hired Ox Plow	Ox Hrs.	16.00	16.95		$\leq$	0
29	Owned Ox Plow Oct.	Ox Hrs.	20.00	25.15		$\leq$	115
30[b]	Owned Ox Plow Nov.	Ox Hrs.	11.02	11.50		$\leq$	98
31	Owned Ox Plow Dec.	Ox Hrs.	5.42	-		$\leq$	73
32[c]	Hired Tractor	Trc. Hrs.	5.50	5.20		$\leq$	0
33	TSP	Kg.	72.00	45.00	72.00	$\leq$	0
34	SA	Kg.	40.00	36.00	40.00	$\leq$	0
35	THDN	Tshs.	13.34	-	13.34	$\leq$	0
36	DDT	Tshs.	-	5.06	-	$\leq$	0
47	OPT CTN	Kg.	-678.50	-	-542.80	$\leq$	0
48	OPT MZE	Kg.	-	-881.00	-	$\leq$	0

Abbreviations: CTN = Cotton; MZE = Maize; FL = Family Labor; TSP = Triple Superphosphate; SA = Sulphate of Ammonia; THDN = Thiodan; OPT = Output; and A = Activity.

[a] Applied only to farmers who hired ox plows.

[b] Applied to farmers who owned ox plows.

[c] Applied to farmers who hired tractors.

and maize, which is grown for the market and for home consumption. In columns A_1 and A_2, two alternative ways of growing cotton are shown--early cotton growing and late cotton growing. Because it results in lower yields per hectare, late planting of cotton is strongly discouraged by the government through political campaigns and close supervision by extension agents. As a result, 95 percent of farm households in the sample planted early cotton. In this study the economic-engineering method was used to include late-planted cotton as an activity. This method was used for analyzing the impact of an alternative farming system on cropping patterns, resource allocation, and net farm income. Because maize is the main food crop, farmers would not take any risk in planting it late. So there is only one activity for maize. Cotton and maize are significant in terms of their contribution to family-food requirements and farm income. Consequently, they were identified as the enterprises that most adequately depict the important production opportunities available to the family farm in the study area.

Other crops such as cassava, sweet potatoes, groundnuts, beans, cowpeas, and vegetables such as tomatoes and cabbages were not included in the crop-production activities for the following reasons. These crops do not compete for land with cotton and maize. Land allocated by the government for cotton and maize cannot be used to grow any other crops. All these crops together constitute about 2 percent of the total area cultivated by each farm household. Third, in growing these crops, there is no apparent competition for labor. For example, cassava and sweet potatoes can be planted much earlier than maize because they are drought-resistant crops. It was observed that most farm households began land preparation for these crops in late August although planting took place in September or early October. Beans, cowpeas, groundnuts, and vegetables also require light rains. They are planted anytime between October and December. With such an extended period of planting, their demand for labor is not as critical as that of cotton and maize. All of these crops are weeded once and this operation can always be left until the labor demand for cotton and maize is low. Cassavas, groundnuts, and sweet potatoes can be harvested anytime after May without affecting yields per hectare, whereas vegetables, beans, and cowpeas are harvested in mid-April when labor demand for cotton and maize is not critical. Finally, the cost of collecting data that includes all these crops was beyond the resources of this study.

The input-output coefficients of the crop-production activities were derived from the survey data. The activity unit (i.e., the amount of crop production that each unit of activity represented) was one hectare. The objective-function coefficients (C_j) for the crop-production activities represented the costs of fertilizers, insecticides, hired labor, working parties, animal owning and hiring, and tractor-hiring services. Negative signs were assigned because costs reduce the income of farmers.

Labor-Hiring Activities

In the study area, family labor available for work on the family farm was augmented by hired labor. Labor-hiring activities are outlined in columns A_4 to A_9 of Table 5.2. The prices used are the wage rates per man-hour prevailing in the study area at the time labor was hired. This was important because wage rates for hired labor varied from one activity to another, depending on the demand for hired labor, availability of labor from working parties and so on.

Table 5.2

Labor - Hiring and Working - Party Activities

ROW	OBJECTIVE Fn. (Cj) / RESOURCES	UNITS	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	SIGN	R.H.S.
			HL Oct.	HL Nov.	HL Dec.	HL Jan.	HL Feb.	HL May	WP Oct.	WP Nov.	WP Dec.	WP Jan.	WP Feb.	WP Apr.	WP May	WP June		
			-3.10	-3.25	-3.87	-4.13	-4.98	-1.85	-0.69	-0.84	-1.05	-0.70	-1.12	-1.07	-0.75	-0.52		
4	FL Oct.	Hrs.	-1						-1								$\leq$	449
5	FL Nov.	Hrs.		-1						-1							$\leq$	426
6	FL Dec.	Hrs.			-1						-1						$\leq$	433
7	FL Jan.	Hrs.				-1						-1					$\leq$	444
8	FL Feb.	Hrs.					-1						-1				$\leq$	476
10	FL Apr.	Hrs.						-1						-1			$\leq$	402
11	FL May	Hrs.							-1						-1		$\leq$	418
12	FL June	Hrs.								-1						-1	$\leq$	431

Abbreviations: HL = Hiring Labor; WP = Working Parties; FL = Family Labor

Table 5.2 Continued

Labor - Hiring and Working - Party Activities

ROW	OBJECTIVE Fn. (C$_j$) / RESOURCES	UNITS	A_4 HL Oct.	A_5 HL Oct.	A_6 HL Dec.	A_7 HL Jan.	A_8 HL Feb.	A_9 HL May	A_{10} WP Oct.	A_{11} WP Nov.	A_{12} WP Dec.	A_{13} WP Jan.	A_{14} WP Feb.	A_{15} WP Apr.	A_{16} WP May	A_{17} WP June	SIGN	R.H.S.
			-3.10	-3.25	-3.87	-4.13	-4.98	-1.85	-0.69	-0.84	-1.05	-0.70	-1.12	-1.07	-0.75	-0.52		
37	OC Oct.	Tshs	3.10						0.69								≤	420.30
38	OC Nov.	Tshs		3.25						0.84							≤	317.75
39	OC Dec.	Tshs			3.87						1.05						≤	223.00
40	OC Jan.	Tshs				4.13						0.71					≤	159.05
41	OC Feb.	Tshs					4.98						1.12				≤	172.40
42	OC Apr.	Tshs												1.07			≤	61.45
43	OC May	Tshs						1.85							0.75		≤	82.20
44	OC June	Tshs														0.52	≤	116.00
50	HL LMT Oct.	Hrs.	1														≤	28.00
51	HL LMT Nov.	Hrs.		1													≤	34.50
52	HL LMT Dec.	Hrs.			1												≤	85.00
53	HL LMT Jan.	Hrs.				1											≤	52.00
54	HL LMT Feb.	Hrs.					1										≤	60.75
55	HL LMT May	Hrs.						1									≤	47.75
56	WP LMT Oct.	Hrs.							1								≤	139.33
57	WP LMT Nov.	Hrs.								1							≤	106.32
58	WP LMT Dec.	Hrs.									1						≤	124.05
59	WP LMT Jan.	Hrs.										1					≤	128.59
60	WP LMT Feb.	Hrs.											1				≤	120.10
61	WP LMT Apr.	Hrs.												1			≤	53.40
62	WP LMT May	Hrs.													1		≤	86.33
63	WP LMT June	Hrs.														1	≤	48.00

Abbreviations: HL = Hiring Labor; WP = Working Parties; OC = Operating Capital; LMT = Limit

These activities have negative coefficients in the family-labor rows, indicating that an increase in one unit of hired labor relaxes the family-labor constraints by one unit. The wage rate of hired labor is positive in the operating-capital rows, meaning that an additional unit of hired labor decreases operating capital by its wage rate. Thus, the amount of hired labor is determined not only by the family-labor constraint but also by the availability of operating capital.

Labor-hiring activities have negative values on the C_j of the objective function because each unit of hired labor reduces the value of the objective function by its wage rate. It should be noted that in the study area, the average farm household was a net buyer of labor; hence the selling of family labor in the form of off-farm work is not provided for in the model.

Working-Party Activities

Unlike hired labor or labor obtained through contract systems (exchange labor), labor from working parties is based on the trust the community has in an individual or a farm household. A farm household invites members of the community to come and work on its farm. All the host farm household provides is food and beer. The community members (mostly farmers) who turn up for the work do not demand any particular type of food or beer. They simply expect to be well fed. The system is different from exchange labor, in which farm households agree to provide labor for each other on arranged days, in the sense that the parties do not discuss any payment either prior to or after the work.

Working parties provide the cheapest labor apart from family labor. However, this is not unlimited labor. The availability of this type of labor depends on how busy other farm households are. During certain farm operations, such as first weeding, most farm households cannot leave their farms and work on another household's farm. In this case, hiring of labor becomes prevalent. Working parties are also constrained by the amount of operating capital available to the farm household. If farmers engage in an alternative farming system (one including late-planted cotton) there are shifts in the demand for working parties, but one cannot tell in advance how such shifts will take place.

Working-party activities are presented in columns A_{10} to A_{17} in Table 5.2. For analysis purposes, the in-kind payments (food and beer) were converted into money terms by multiplying the quantity received by its existing price or (where this was impossible) by having the farmers evaluate the food and beer provided.

For all farming operations, family labor, hired labor, and labor from working parties were assumed to be perfect substitutes. As with labor-hiring activities, working-party activities have negative coefficients in the family-labor rows, indicating that an increase in one unit of labor from working parties relaxes the family labor constraints by one unit. Similarly, the payment to this type of labor is positive in the operating-capital rows, meaning that an additional unit of this labor decreases operating capital by the amount paid.

These activities have negative C_j values in the objective function since each unit of working-party labor reduces the value of the objective function by the amount paid to it. The average farm household in the study area is a net user of labor from working parties. Hence the use of family labor in the form of working parties is not provided for in the model.

Animal-Power Hiring Activities

These activities are presented in columns A_{20} to A_{26} of Table 5.3. The prices used are the rents paid per hectare. Animals hired for farm work usually include an ox team; one or two men come to drive the team. For land cultivation and ridging, family labor, hired labor, community labor and animals hired (after appropriate conversions) are assumed to be nearly perfect substitutes. The animal-hiring activities have negative coefficients of five in the family labor rows, indicating that for land cultivation and ridging an additional unit of animals hired relaxes five units of family labor constraints.

The hiring of animals decreases the operating capital by cost of rent per hectare. Thus, the availability of operating capital determines the extent to which animal power can be substituted for family labor.

Animal-hiring activities have negative C_j values in the objective function since each unit of hired animal power reduces the value of the objective function by the amount paid per hectare.

Animal-Power Owning Activities

A number of farm households in the study area own ox plows that are used to augment the stock of family labor available for cultivating and ridging the land. These activities are outlined in columns A_{21} to A_{23}

Table 5.3

Ox Plow-Owning, Ox Plow-Hiring, and Tractor Hiring Activities[a]

ROW	Objective Fn. (Cj.) / RESOURCES	UNITS	A_{18} CTN CULT. (LAB)	A_{19} CTN RIDGE (LAB)	A_{20} CTN (HIRE OX PLOW)	A_{21} OWN OX PLOW	A_{22} CTN CULT. (OWN OX PLOW)	A_{23} CTN RIDGE (OWN OX PLOW)	A_{24} MZE CULT. (LAB)	A_{25} MZE RIDGE (LAB)	A_{26} MZE (HIRE OX PLOW)	A_{27} MZE CULT. (OWN OX PLOW)	A_{28} MZE RIDGE (OWN OX PLOW)	A_{29} CTN HIRE TRACTOR	A_{30} MZE HIRE TRACTOR	SIGN	R.H.S. 0
			0	0	-180.00	0	0	0	0	0	-180.00	0	0	-300.00	-300.00		
4	FL Oct.	Hrs.	145.46						176.62							≤	440
5	FL Nov.	Hrs.		133.55	-5.00	-5.00	20.00	11.02		105.06	-5.00	25.15	11.50	-15.00	-15.00	≤	426
37	OC Oct.	Tshs			180.00									300.00	300.00	≤	420.30
38	OC Nov.	Tshs					3.33				180.00	3.33				≤	317.75
39	OC Dec.	Tshs						3.33					3.33			≤	223.00
64	CTN Land Cult. Capacity	Ha	-1	1			-1	1						-1		≤	0
65	CTN Ridge Capacity	Ha		-1	-1			-1								≤	0
66	Own Ox Plow Cult. Capacity	Ha				-115.00	20.00					25.15				≤	0
67	Own Ox Plow Ridge Capacity	Ha				-90.00		11.02					11.50			≤	0
68	MZE Land Cult. Capacity	Ha							-1	1		-1	1		-1	≤	0
69	MZE Ridge Capacity	Ha								-1	-1		-1			≤	0
70	LMT Ox Plow Hire for CTN	Ox Hrs.			1											≤	23.00
71	LMT Ox Plow Hire for Mze	Ox Hrs.									1					≤	18.50
72	LMT Tractor Hire for CTN	Tractor Hrs.												1		≤	5.50
73	LMT Tractor Hire for MZE	Tractor Hrs.													1	≤	5.30

[a]These activities were independently computed for farmers who (1) employed labor; (2) employed labor with owned ox plow; (3) employed labor with hired ox plow; and (4) employed labor with hired tractor power.

Abbreviations: CTN = Cotton; MZE = Maise; CULT. = Cultivation; LAB = Labor; FL = Family Labor; OC = Operating Capital; and LMT = Limit.

and A_{27} to A_{28} of Table 5.3. An average farm household in the study area has four oxen and ox-drawn equipment that can work for an average of 250 ox-hours a year. Hourly operating costs were based on depreciation, interest, housing, veterinary costs, and so on.[1] Based on these factors, the hourly operating cost is Tshs 3.33.

Animal-power owning activities reduce the value of the objective function; they are, therefore, assigned negative coefficients in the objective function. Since ox plows can substitute labor for land cultivation and ridging, there are cotton cultivation and ridging as well as maize cultivation and ridging by owned-animal-power activities. These are assigned zero coefficients. However, animal-power owning activity requires labor to run it. So there are positive family-labor coefficients in the family-labor rows, meaning that any use of animal power depletes family labor by the number of hours indicated.

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[1](a) Depreciation: Purchase price for 4 oxen @ Tshs 450, 1 plow at Tshs 350; and 1 cart at Tshs 1700. Use-life for ox assumed to be 4 years each; for plow, 5 years; and for cart, 6 years. Total cost for six years is Tsh 4825; less resale value of Tshs 525 for each ox at slaughter: (4825-2100) = 2725. Assuming straight-line depreciation, annual cost = Tshs 454.

(b) Interest: Charges at 8½ percent on Tshs 2725 compounded over 6 years = 287/year.

(c) Maintenance: Usually consists of feed requirements, but since oxen in the area are grazed on communal land, the opportunity cost of maintenance is taken to be zero. However, the oxen are lightweight (200-250 kg) and their work effort is very low. A day's work is not more than 4 hours.

(d) Housing, veterinary, etc. These are charged at 20 percent of depreciation on 91 Tshs per year.

Cost of oxen and equipment based on data from Work Bank, Appraisal of the National Maize Project, Report No. 89a/TA, Washington, D.C. Dec. 8, 1975, and field notes. Costs updated for 1980. The project was conducted for the United Republic of Tanzania.

Tractor-Hiring Activities

In columns A_{29} and A_{30} of Table 5.3, tractor hiring activities are outlined for the representative farm in the model. The prices used are the rents paid per hectare. For land cultivation, the following are assumed to be nearly perfect substitutes; family labor, hired labor, working parties, and hired animal power (after appropriate conversions). They have negative coefficients of 15 in the November family-labor row, indicating that for land cultivation an additional hour of hired tractor use releases 15 units of family-labor constraint.

The hiring of tractors decreases the operating capital by cost of rent per hectare. Thus, the availability of operating capital determines the extent to which tractors can be substituted for family labor. Tractor-hiring activities have negative C_j values in the objective function since each unit of hired-tractor power reduces the value of the objective function by the amount paid per hectare.

Fertilizer- and Insecticide-Buying Activities

In Table 5.4, columns A_{31} to A_{34} fertilizer- and insecticide-buying activities are listed. Farmers buy two types of fertilizers (triple super-phosphate (TSP) and sulphate of ammonia (SA) and two types of insecticides, Thiodan and DDT. Although the two types of fertilizers are used for both cotton and maize, Thiodan is sprayed only on cotton and DDT only on maize.

Data on different levels of fertilizers and insecticides needed to test their economic impact on farmers net farm income and resource allocation was not available. Consequently, only one level for each of those inputs was used in the analysis.

Table 5.4

Fertilizer - and Insecticide - Buying and Selling Activities, and Food Consumption Activity

ROW	OBJECTIVE Fn. (Cj.) / RESOURCES	UNITS	A_{31} BUY TSP	A_{32} BUY SA	A_{33} BUY THDN	A_{34} BUY DDT	A_{35} SELL CTN.	A_{36} SELL MZE.	A_{37} CONS. MZE.	A_{38} RENT OX PLOW OCT.	A_{39} RENT OX PLOW NOV.	SIGN	R.H.S.
			-1.34	-1.03	-13.34	-5.06	3.20	2.50	0	180.00	180.00		
4	FL Oct.	Hrs.								55.15		≤	449
5	FL Nov.	Hrs.									40.10	≤	426
29	Own Ox Plow Oct.	Ox Hrs.								1		≤	115
30	Own Ox Plow Nov.	Ox Hrs.									1	≤	98
33	TSP	Kg.	-1									≤	0
34	SA	Kg.		-1								≤	0
35	THDN	Tshs.			- 1							≤	0
36	DDT	Tshs.				-1						≤	0
37	OC Oct.	Tshs.	1.34							-180.00		≤	420.30
38	OC Nov.	Tshs.		1.03							-180.00	≤	317.75
39	OC Dec.	Tshs.			13.34							≤	223.00
45	OC June	Tshs.				5.06	-3.20	-2.50				≤	116.00
46	OC July	Tshs.					-3.20					≤	0
47	OPT CTN.	Kg.					1					≤	0
48	OPT MZE.	Kg.						1				≤	0
49	CONS. MZE.	Kg.							1			≤	346
66	Own Ox Plow Cult. Capacity	Ha								55.15		≤	0
67	Own Ox Plow Ridge Capacity	Ha									40.10	≤	0

Abbreviations: TSP = Triple Superphosphate; SA = Sulphate of Ammonia; THDN = Thiodan; CTN = Cotton; MZE = Maize; CONS. = Consumption; FL = Family Labor; OC = Operating Capital; OPT = Output

The prices of these activities reflect the cost associated with the purchase of these inputs. The prices used are those prevailing in the area in the 1980-81 season. The C_j values of these activities are negative since they reduce the value of the program. The activities have negative coefficients in the row columns indicating that an increase of one unit of fertilizer or insecticide in the basis increases the stock (assumed initially at zero levels) of these inputs. The positive coefficients in the operating-capital rows show that the purchase of fertilizer and insecticide requires an expenditure of operating capital equal to the price of the fertilizer or insecticide.

The prices of these inputs are fixed by the government prior to the farming season. Farmers are subsidized, so the prices used in the model are subsidized prices. TSP is subsidized by about 30 percent, SA by 40 percent, Thiodan by 50 percent, and DDT by about 80 percent. These prices are indicated by C_j values.

Consumption Activities

When this model was formulated, it was assumed that household food consumption is satisfied before any sale activities are undertaken. In this study there is only one consumption activity, which is shown in Table 5.4, column A_{37}. The minimum household-consumption requirements were determined from the farm-survey data. The positive coefficients attached to the consumption activity indicate that one unit of the j^{th} commodity to be consumed depletes the corresponding output in the output row.

Crop-Selling Activities

Crop-selling activities are shown in Table 5.4 columns A_{35} and A_{36}. The model is contracted in such a way that the selling of food crops takes place only after consumption needs have been satisfied. It is also assumed that selling prices reflect the cost of storage; therefore, no storage activities are included in the model. The price of maize (C_j value) is that prevailing in the local (black) market in 1980-81. Local markets are assumed to be competitive, and prices usually differ from the government-controlled price. There is no black market for this crop.

The objective-function coefficients are positive because selling adds to the value of the objective function. The row coefficients of the output of the crops are also positive since selling activities reduce the stock of that crop.

Animal-Power Selling Activities

These activities are shown in Table 5.4, columns A_{38} and A_{39}. When a farmer owns an ox plow, he is likely to rent it to other farmers after employing it on his own farm. This is very common in the area. It is a source of income that farmers need to meet their cash expenses.

These activities have positive coefficients in the family-labor rows, indicating that a unit increase in the level of these activities reduces the amount of family labor available by the value of the coefficient. The same can be said for the positive coefficients in the animal-power owning rows. The negative coefficients in the operating-capital rows indicate that a unit of animal power sold increases operating capital by the amount shown. The objective function coefficients are positive because selling adds to the value of the program.

Transfer Activities

In columns A_{40} to A_{47} of Table 5.5, activities are represented that are used to pass surplus capital from one month to the next month during the farming season, even if this transfer is not required directly to finance operations (Barnard and Nix, p. 443). These activities have zero value in the objective function, a positive sign for the last month in the operating-capital row, and a negative sign on the amount-of-transfer row, which means that the capital accumulation at the end of the crop year is increased.

Restrictions in the Model

In the study area, farmers are faced with certain restrictions or contraints in their production activities. These restrictions are outlined in Tables 5.1 to 5.5 in the columns labeled R.H.S. The restrictions are all defined below.

Agricultural-Land Restrictions

The land available to the representative farms influences both the acreage allocated to various crops and the cropping patterns undertaken by the farm firm. In the study area, land for cotton and maize is allocated by local government officials. Farmers are not expected to grow crops other than those on land allocated. No farmer is allowed either to sell or buy land. There was no evidence of land renting. Consequently, in the linear programming model, these options are not provided for.

Table [illegible]

Transfer A[illegible]

Row	Objective Fn. (Cj.) / Resources	Units	A_{40}	A_{41}	A_{42}	A_{43}	A_{44}	A_{45}	A_{46}	A_{47}	A_{48}	A_{49}	Sign	R.H.S.
			TOC Oct.-Nov.	TOC Nov.-Dec.	TOC Dec.-Jan.	TOC Jan.-Feb.	TOC Feb.-Mar.	TOC Mar.-Apr.	TOC Apr.-May	TOC May-June	TOC June-July	TRANSFER COLUMN		
			0	0	0	0	0	0	0	0	0	0.0001		
37	OC-Oct.	Tshs	1										≤	420.30
38	OC-Nov.	Tshs	-1	1									≤	317.75
39	OC-Dec.	Tshs		-1	1								≤	223.00
40	OC-Jan.	Tshs			-1	1							≤	159.05
41	OC-Feb.	Tshs				-1	1						≤	172.40
42	OC-Mar.	Tshs					-1	1					≤	0
43	OC-Apr.	Tshs						-1	1				≤	61.45
44	OC-May	Tshs							-1	1			≤	82.20
45	OC-June	Tshs								-1	1		≤	116.00
46	OC-July	Tshs									-1	1	≤	0
74	Ending Capital	Tshs										1	≤	420.30

Abbreviations: TOC = Transfer of Operating Capital; OC - Operating Capital

Labor Constraints

Family labor restrictions are specified on a monthly basis in the model.[2] The row unit is man hours. The amount of family labor available to each representative farm for each month was estimated from the farm-survey data. The family-labor stock could be supplemented by labor hiring or by labor obtained through working parties. The amount of the last two types of labor, however, depends on the total labor requirement relative to the amount of family labor available, the amount of hired labor available in relation to its wage rate, the amount of labor from working parties, and the amount of operating capital, both cash and food.

Operating-Capital Restrictions

In this study, cash expenses were used as an indication of the amount of operating capital. Part of these cash expenses, however, were derived from payments in kind (food and beer) for working parties. Food and beer offered for working parties were valued in Tanzanian shillings. The amount of funds available for cash expenses on the representative farm was set equal to the amount estimated to have been spent on hired labor, working parties, fertilizers, insecticides, hiring of ox teams,

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[2]Beneke and Winterboer (p. 64) indicated that including a single labor restraint implies that labor can be freely substituted among seasons of the year. Labor is likely to have different opportunity costs in different seasons. Realistic planning requires taking account of the seasonality of labor requirements and restraints. Restraints should be formed to focus on those periods of the year in which labor allocation is critical. The remaining noncritical periods can also be included to provide a complete accounting of labor within the system.

and hiring of tractors for the crop-production activities during the 1979-80 cropping season. These were estimated from the data obtained in the survey conducted for this study.

The operating-capital constraints were also specified on a monthly basis. Barnard and Nix (p. 439) offered two primary ways of incorporating operating capital into a linear programming matrix. One is to use transfer activities to pass surplus capital from one period to another during the year. The other is to accumulate capital balances in successive periods. In this study, transfer activities were used to pass surplus funds from one month to another during the cropping year.

There was no data on short-term credit availability or savings. Thus, no borrowing activities was included in the linear programming models to supplement operating capital. Hence the operating-capital restriction used was the minimal estimate of capital availability. However, this restriction was relaxed in the analysis by the assumption that increases in farmers' incomes due to increased product prices would lead to an increase of 10 percent in operating capital.

Food-Consumption Constraint

It was assumed that the representative farmer is motivated by the "first security rule," that is, the first priority is to produce the family's food-consumption requirements. Therefore, the farmer needs to produce the minimum amount of maize for the family consumption. Thus, a minimum amount. The amount of food consumed was estimated from the survey data. These data were aggregated to obtain the average consumption of the household per year. The average was then used as a constraint for maize produced by the farm firm.

Nonnegative Restriction

One of the requirements for the use of linear programming is the nonnegativity of the activities in the model. None of the activities discussed above could be operated at negative levels.

Some Limitations of the Model

What has just been presented does not exhaust the list of activities and restrictions that could be included in a linear programming model of small-farm agriculture. Examples of activities not included in the model would be the following: nonfarm activities of family members; various types of the activities in the farming process, including production of cassava, sweet potatoes, groundnuts, beans and cowpeas. Additional levels of fertilizer or insecticide use could have been included as separate activities. The number of activities in the model depends on the availability of data and the objectives of the study.

Large and complex models such as systems simulations, which are valuable for analyzing domains of problems, both of economic and noneconomic disciplines (Dent and Anderson; Manetsch) are costly in terms of time, money, and other resources. It is not always certain that the benefits to be derived from additional activities in terms of precision for planning purposes are sufficient to justify the additional costs of employing a systems approach for analyzing the defined problem. Further, results from such complex models may be difficult to interpret in terms of tracing the logical causal relationships between a change in this study was kept as simple as possible but complete enough to reflect the farm situation in the area of the study.

In this chapter, a detailed description of the structure of the linear-programming models employed in this study and how the supporting data was generated were presented. The application of the models as described here and their variants are presented in Chapter VI.

CHAPTER VI

ANALYSES OF THE RESULTS OF THE APPLICATION OF THE LINEAR-PROGRAMMING MODELS

In this chapter, the analysis is presented of the results of the application of the linear-programming models for the participant and nonparticipant representative farms. The analysis is focused on: (1) the possibilities of increasing farm income through improved allocation of existing resources; (2) the determination of optimal cropping patterns under existing resource constraints, prices, and technology; and (3) the extent of resource use and productivity. At a later stage, the impact of changing relative product prices, input prices, and operating-capital level on farm income, cropping patterns, and resource use is explored.

First, the product price was varied while other resources, input prices, and operating capital remain unchanged. There were three relative product-price changes. These were 0 percent and 80 percent; 25 percent and 80 percent; and 25 percent and 150 percent increases for cotton and maize, respectively. These price increases were in keeping with the government-price changes that ranged from zero percent between the 1975-76 and 1976-77 farm seasons to 25 percent between the 1979-80 and 1980-81 season for cotton; and market-price increases for maize (within Mwanza region) that ranged from 80 percent to 150 percent above the government price between July and October 1980. Many farmers interviewed by the researcher confirmed that such unofficial price increases for maize have been common since the late 1960s and have since been used in decision making.

Second, input prices, especially those of fertilizer and insecticide were increased by up to 30 percent for TSP, 40 percent for SA, 80 percent for DDT, and 50 percent for Thiodan, with existing product prices, other resources, and operating capital remaining unchanged. These increases caused the farmers to pay the actual input prices, which were subsidized by the respective percentages. The goal was to lower these subsidies as farmers' incomes increased.

Finally, the operating-capital levels were increased by 10 percent (if the resource was limiting) with existing resources; product and input prices remained unchanged. The purpose of this increase was that, given favorable product prices, farmers' incomes would increase, and, in turn, farmers would increase their operating-capital levels.

In the first section of this chapter, a discussion is presented of the comparison of the optimal plan of the participants' representative farm enterprises under (1) the maize and early-cotton farming system; and (2) under the maize, early-cotton, and late-cotton farming system. The comparisons are based on the changes on farm income, resource use and productivity, and return to resources. In the second section of the chapter, a review is included of nonparticipants' representative farm enterprises in order to curve a basis for comparing the optimal plan between the participants and nonparticipants in the cotton project in Geita District financed by the World Bank.

The objective of the third section is to show the different effects of improved agricultural practices (such as use of better seeds, recommended amounts of fertilizers and insecticides, and recommended number of weedings) on enterprise combinations, resource use and productivity, and average returns to limiting resources. A summary of the results of the various linear-programming analyses is given in the final section of the chapter.

Optimal Organization of Existing Resources and Prices for Participants, Model A

Mechanization and Manual Technologies: Maize and Early Cotton

In Table 6.1 a comparison is given of bench-mark and optimal organizations of the representative farm in the Geita cotton project. Four models are shown in the table: one for only labor user (A_1); one for farmers employing labor and owned ox-drawn equipment (A_2); one for those hiring ox-drawn equipment in addition to using labor (A_3); and one for farmers using labor and hiring tractors (A_4). As a basis for comparison, the following economic measures were employed: net farm income per hectare, net farm income per man hour, and net farm income per unit of operating capital.

The optimum net farm income for Model A_1 totaled Tanzanian shillings (Tshs) 4450.96 compared to Tshs 3884.47 from the actual average for the representative farm in the sample. This represented a 14.58 percent increase. The optimum plan included 2.05 hectares for cotton compared to 1.29 hectares from the actual average, and 0.39 hectares for maize compared to 1.23 hectares. These represented an increase of 58.91 percent and a decrease of 68.29 percent for cotton and maize respectively. The big decrease in hectarage planted in maize requires some explanation. The price of maize used in deriving the optimal organization was the official price of Tshs 1.00. Based on this price, farmers would plan to grow maize for household consumption only and very little if any for market

Table 6.1

Comparison of Bench-Mark[a] and Optimal Organizations Under Existing Resources and the Official Price for Maize and Early Cotton for Participants

ITEM	UNIT	BENCH-MARK[b]	OPTIMAL ORGANIZATIONS							
			Model A_1	% Change	Model A_2	% Change	Model A_3	% Change	Model A_4	% Change
Net Farm Income (NFI)	Tshs	3884.47	4450.96	+14.58	4675.26	+20.35	4516.09	+16.26	4450.96	+14.58
Land (Cotton)	Ha	1.29	2.05	+58.91	2.23	+72.87	2.08	+61.24	2.05	+58.91
Land (Maize)	Ha	1.23	0.39	-68.29	0.39	-68.29	0.39	-68.29	0.39	-68.29
Total Land	Ha	2.52	2.44	+ 6.5	2.62	+ 3.96	2.47	- 1.98	2.44	+ 6.5
Family Labor	Hrs	2843.70	3466.94	+21.92	3527.85	+24.06	3491.18	+22.77	3466.94	+21.92
Hired Labor	Hrs	298.00	3.57	-96.10	3.57	-96.10	3.57	-96.10	3.57	-96.10
Working Party	Hrs	807.00	301.29	-62.66	393.07	-51.29	400.87	-50.32	301.29	+62.66
Total Labor	Hrs	3948.70	3771.80	- 4.47	3924.49	- 0.61	3895.62	- 1.34	3771.80	+ 4.47
[c]Ox Team (Owned)	Ox Hrs	75.09	-	-	78.08	+ 3.98	-	-	-	-
[d]Ox Team (Hired)	Ox Hrs	41.50	-	-	-	-	38.64	- 6.89	-	-
[e]Tractor (Hired)	Trac. Hrs	5.35	-	-	-	-	-	-	0	-100
Operating Capital	Tshs	1552.15	673.28	+56.62	834.67	-46.22	982.30	-36.71	673.28	+56.62
NFI/Ha	Tshs	1541.45	1824.16	+18.34	1784.45	+15.76	1828.38	+18.61	1824.16	+18.34
NFI/Hr of Unpaid Labor	Tshs	1.36	1.28	- 5.88	1.32	- 2.94	1.29	- 5.14	1.28	- 5.88
NFI/Operating Capital	Tshs	2.50	6.61	+84.4	5.60	+124.00	4.59	+87.6	6.61	+84.4

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[a]The bench-mark organization is included in this and subsequent tables to facilitate comparisons.

[b]In this and subsequent tables, the bench-mark is the actual farm defined from coefficients generated from representative farms.

[c,d,e]These are not employed together. Farmers employ either labor alone (Model A_1) or labor and owned ox team (A_2), labor and hired ox team (A_3) or labor and hired tractor (A_4).

Since less land was used, most resource use also decreased. Whereas family labor increased by 21.92 percent, hired labor and labor from working parties decreased by 96.10 percent and 62.66 percent respectively. Total labor decreased by 4.47 percent.

Operating capital also decreased from Tshs 1552.15 to Tshs 673.28, or a 56.62 percent decrease. The decrease in cash and payment in kind resulted from the decrease in the use of hired labor, working parties, and inputs such as fertilizers and insecticides. The average per hectare income was Tshs 1824.16, an 18.35 percent increase. The return per hour of family laber was Tshs 1.28 compared to Tshs 1.36, a 5.88 percent decrease, whereas that of a unit of operating capital was Tshs 6.61 compared to Tshs 2.50, an 84.4 percent increase.

When the use of owned animal-drawn equipment was introduced (Model A_2), the area planted in cotton increased from 1.29 hectares to 2.23 hectares, an increase of 72.87 percent. The area planted in maize remained unchanged. Consequently, the optimum net farm income came to Tshs 4675.26 compared to 3884. 47 from the actual average. This was a 20.35 percent increase.

As as result of more land being used in the optimal organization, it would be expected that total labor use would increase. However, farmers devoted fewer hours during land preparation because of the employment of owned ox-drawn equipment. The analysis showed that land preparation accounted for only 102 man hours per hectare (compared to 264 man hours per hectare in Model A_1). Since ox-drawn equipment was used on land preparation alone, time saved in the early part of the farming season was almost compensated for by the increased labor

required for later weedings. Thus, despite the increased cropping area, total labor use declined by 0.61 percent. Most of this decline came from hired labor (96.10 percent) and from working parties (51.29 percent). Family labor increased from 2843.70 man hours to 3527.85 man hours, or a 24.06 percent increase. Use of owned ox-drawn equipment increased by 3.98 percent from the actual average in the sample.

As a result of changes in the use of hired labor, working parties, owned ox-drawn equipment, and operating capital decreased by 46.22 percent. The net farm income per hectare was Tshs 1784.45 compared to Tshs 1541.45, a 15.76 percent increase. The net farm income per man hour of family labor decreased from Tshs 1.36 to Tshs 1.32, a 2.94 percent decrease whereas that of a unit of operating capital was Tshs 5.60 compared to Tshs 2.50, an increase of 124 percent.

In Model A_3 (use of labor and hired ox-drawn equipment) the cotton area increased from 1.29 hectares to 2.08 hectares, an increase of 61.24 percent. There was no change in area planted in maize. As a result of these changes, use of family labor increased by 22.77 percent, whereas hired labor and labor from working parties decreased by 96.10 percent and 50.32 percent respectively. Total labor decreased by 1.34 percent; this decline was explained by the decrease in total area cropped as well as by employment of hired ox-drawn equipment. Operating capital decreased from Tshs 1552.15 to Tshs 982.30, a 36.71 percent decrease.

Although the net farm income per hectare increased from Tshs 1541.45 to Tshs 1828.38, an increase of 18.61 percent, the net farm income per man hour of family labor declined by 5.14 percent, and the income per unit of operating capital increased by 87.6 percent.

The optimal organization for Model A_4 was similar to that of A_1. Hired tractor services were not included in the optimal solution. This left labor activities to determine the optimal organization. Since labor coefficients and the other coefficients in Model A_4 were the same as those in A_1, the optimal results of the two models were the same.

In deciding how to allocate farm resources between the two crops, however, farmers did not use the official price for maize. In contrast to cotton, it is easy to find buyers for maize in the black market; these buyers pay a much higher price. This price is determined competitively in the food market. It was observed during the research that the price for a kilogram of maize was about Tshs 1.50 to 1.80 during the period immediately following harvest, but increased quite sharply to Tshs 2.50 within two to three months. Through observation and informal discussions with farmers in the area, it was concluded that many farmers made their resource-allocation decisions on an expected maize price of Tshs 2.50 per kilogram. It was learned that this practice has been going on for the last six years and is likely to continue in the future.

In Table 6.2, a comparison is given of bench-mark and optimal organizations of representative farms when the official price for maize was replaced by a free-market price of Tshs 2.50. The results of the analysis showed that in Model A_1, the area planted in maize increased from 1.23 hectares to 1.30 hectares, or an increase of 5.69 percent from the bench-mark average. The area planted in cotton increased from 1.29 hectares in the bench-mark average to 1.65 hectares in the

Table 6.2

Comparison of Bench-Mark and Optimal Organizations Under Existing Resources, The Official Price for Early Cotton and the Free-Market Price for Maize for Participants

ITEM	UNIT	BENCH-MARK	OPTIMAL ORGANIZATIONS							
			MODEL A_1	% CHANGE	MODEL A_2	% CHANGE	MODEL A_3	% CHANGE	MODEL A_4	% CHANGE
Net Farm Income (NFI)	Tshs	4706.86	5538.46	+17.67	5729.60	+21.73	5614.93	+19.29	5538.46	+17.67
Land (Cotton)	Ha	1.29	1.65	+27.91	1.65	+27.91	1.65	+27.91	1.65	+27.91
Land (Maize)	Ha	1.23	1.30	+ 5.69	1.37	+11.38	1.32	+ 7.32	1.30	+ 5.69
Total Land	Ha	2.52	2.95	+17.06	3.02	+19.84	2.97	+17.85	2.95	+17.06
Family Labor	Hrs	2843.70	3684.99	+22.82	3761.99	+32.29	3695.16	+29.94	3684.99	+22.82
Hired Labor	Hrs	298.00	104.53	-64.74	104.53	-64.74	104.53	-64.74	104.53	-64.74
Working Party	Hrs	807.00	652.72	-19.53	718.06	-11.02	687.31	-14.83	652.72	-19.53
Total Labor	Hrs	3948.70	4442.24	+12.52	4584.58	+16.10	4487.00	+13.63	4442.24	+12.52
Ox Team (Owned)	Ox Hrs	75.09	-	-	89.98	+19.82	-	-	-	-
Ox Team (Hired)	Ox Hrs	41.50	-	-	-	-	46.82	+12.82	-	-
Tractor Hired	Trc. Hrs	5.35	-	-	-	-	-	-	0	-100
Operating Capital	Tshs	1552.15	1026.74	-33.85	1241.35	-20.02	1304.40	+15.96	1026.74	-38.85
NFI/Ha	Tshs	1867.80	1877.44	+ 0.50	1897.21	+ 1.58	1890.55	+ 1.22	1877.44	+ 0.50
NFI/Hr of Unpaid Labor	Tshs	1.66	1.50	- 9.64	1.52	- 8.43	1.51	- 7.83	1.50	- 9.64
NFI/Operating Capital	Tshs	3.03	5.39	+78.03	4.62	+52.33	4.30	+42.07	5.39	+78.03

optimal organization. This represented an increase of 27.91 percent. Consequently, the optimum net farm income came to Tshs 5538.46 compared to 4706.86 from the bench-mark average. This was a 17.67 perent increase.

As a result of more land being used in the optimal organization, total labor use increased from 3948.70 man hours in the bench-mark average to 4442.24 man hours in the optimal organization, a 12.53 percent increase. All the increase, however, came from family labor, which increased by 22.82 percent. The use of hired labor and labor from working parties decreased by 64.74 percent and 19.53 percent respectively. Changes in the use of hired labor and labor from working parties led to a decrease in the use of operating capital from Tshs 1552.15 in the bench-mark average to Tshs 1026.74 in the optimal solution. The change represented a 33.85 percent fall.

Although there was a 17.67 percent increase in the optimum net farm income, the optimum net farm return per hectare increased by 0.50 percent, and the return per hour of unpaid labor actually fell by 9.64 percent. In the optimal organization, more land and more labor were used in the production of cotton and maize. This explains why the returns to land increased by a small percentage and the return to family labor fell. The net farm income per unit of operating capital, however, increased remarkably from Tshs 3.03 in the bench-mark average to Tshs 5.39, an increase of 78.03 percent. This remarkable increase was explained by the increase in the optimum net farm income on the one hand, and on the other, by a substantial decrease in the optimal amount of operating capital used.

In Model A_2, the inclusion of owned ox-drawn equipment led to some notable changes in the use of resources. Although the area planted in cotton remained the same as that in Model A_1 (i.e., increased by 27.91 percent from that in the bench-mark average), the area planted in maize increased by 11.38 percent from the bench-mark average (and by about 5.38 percent above that in Model A_1). Total land use increased from 2.52 hectares in the bench-mark average to 3.02 hectares in the optimal organization, an increase of 19.84 percent. The net farm income increased from Tshs 4706.86 to 5729.60, representing a 21.73 percent increase from the bench-mark average.

The increase in land use led to an increase in total labor use of 16.10 percent from the bench-mark average. This increase was wholly accounted for by the increase in family labor used, which increased from 2843.70 man hours to 3761.99 man hours, an increase of 32.29 percent. Most of the increase in family-labor use came during weeding, although some increases were also noted during ridging. The results indicated that during land preparation, family-labor use was only 126 man hours per hectare (compared to 267 man hours in Model A_1). During weeding, family-labor use increased from 394 man hours per hectare in Model A_1 to about 450 man hours per hectare. The reason (as explained earlier in this chapter) was that weeding was still done by labor. Use of hired labor and labor from working parties declined by 64.74 percent and 11.02 percent respectively. Further, the use of owned ox-drawn equipment increased from 75.09 ox hours in the actual average to 89.98 ox hours; this represented an increase of 19.82 percent.

The changes in the use of farm resources discussed above led to a decline in the amount of operating capital used; it declined from Tshs 1552.15 to Tshs 1241.35, representing a 20.02 percent fall. The net farm income per hectare, and per unit of operating capital increased by 1.58 percent, and 52.33 percent respectively, whereas the return to unpaid labor decreased by 8.43 percent.

In Model A_3, the change in the area planted in cotton was the same as in Models A_1 and A_2. The area planted in maize increased from 1.23 hectares in the actual average to 1.32 hectares, an increase of 7.32 percent. Compared to Models A_1 and A_2, this change was better than that in the former model and worse than in the latter. This indicated that the use of owned ox-drawn equipment might be more profitable than that of hired ox-drawn equipment. (See also the difference in the net farm incomes for Models A_2 and A_3). The net farm income increased from Tshs 4706.86 to Tshs 5614.93, and increase of 19.29 percent.

The use of family labor increased by 29.94 percent whereas that of hired labor and labor from working parties decreased by 64.74 percent and 14.83 percent respectively. Labor use as a whole increased by 13.63 percent with the whole increase accounted for by the increase in the use of family labor. The decline in the use of family labor during land preparation was not as substantial in this model as it was in Model A_2 (126 man hours per hectare in Model A_2 compared to 241 man hours in A_3). The reason was that part of land cultivation was done by labor and part by hired ox-drawn equipment; the use of hired ox-drawn equipment was limited by the amount of available operating capital in October and November (see Table 6.3). Although in the actual average, 41.50 ox hours were hired, in the optimal organization 46.82 ox hours were hired. This was an increase of 12.82 percent. Operating capital decreased from Tshs 1552.15 to Tshs 1304.40, or a 15.96 percent fall.

There were increases in net farm income per hectare, and per unit of operating capital. Net farm income per hectare increased from Tshs 1867.80 in the actual average to Tshs 1890.55 in the optimal organization. This represented an increase of 1.12 percent. Although net farm income per unit of operating capital increased from Tshs 1867.80 to 1890.55, a 1.22 percent increase, that per unit of unpaid labor decreased from Tshs 1.66 to Tshs 1.51, a decrease of 7.83 percent.

Again, the results for Model A_4 were the same as those for Model A_2 since the hiring of tractor services was not included in the optimal organization. The exclusion of tractor-hiring activity in the optimal organization was explained primarily by the cost of hiring it. It cost almost Tshs 300 per hectare to hire a tractor compared to about Tshs 180 per hectare to hire an ox team.

The results in Table 6.2 clearly show that risk on food production was removed when the black market price for maize was used in the analysis. Compared to the analysis under the official price for both cotton and maize, the black market price for cotton increased the area in maize by about seven times. Even under poor weather and other adverse conditions, this expansion in maize hectarage could produce enough food for household consumption. Further, year to year higher variability in cotton yields (as expressed by many farmers during

Table 6.3

Marginal-Value Products (MVPs in Tshs) of Resources[a] for Models A_1 to A_4 for Participants

RESOURCE	UNIT	MODEL A_1		MODEL A_2		MODEL A_3		MODEL A_4	
		PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50	PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50	PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50	PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50
FL Oct.	Hr	1.90	2.99	0	0	0	0	1.90	2.99
FL Nov.	Hr	2.41	2.75	3.69	2.87	2.88	2.59	2.41	2.75
FL Dec.	Hr	0	1.08	0.47	1.60	0	1.40	0	1.08
FL Jan.	Hr	0.93	0.93	2.05	1.28	2.30	1.19	0.93	0.93
FL Feb.	Hr	0	1.12	0	2.03	0	2.21	0	1.12
FL May	Hr	0	0.95	0	1.16	0	1.76	0	0.95
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
OC Oct.	Tshs	0	0.49	0	0.81	0	0.98	0	0.49
OC Nov.	Tshs	0	0.49	0	0.20	0	0.07	0	0.49
WP LMT Oct.	Hr	0.25	1.37	0	0	0.45	0	0.25	1.37
WP LMT Nov.	Hr	0.61	1.66	0.84	1.79	0.63	1.52	0.61	1.66

[a]In this and subsequent tables, resources not included have zero marginal products in all models.

informal and formal interviews) means that any solution that leads to more production of maize stabilizes farmers' net farm income

The results, shown in Tables 6.1 and 6.2, deviated substantially from the farmers' current practices. This deviation is a reminder that linear programming is an exercise in normative economics. Based on the assumptions used and the constraints given, it indicates how the farmers' incomes could be maximized. It should be noted, however, that the omission of still other factors from the models may prevent the models from representing in the study all aspects of farmers' behavior.

Marginal-Value Products of Resources Under Model A

The marginal-value product (MVP) of disposable activites is defined as the increase in the value of total output that is obtained from the use of additional units of the resource with all other inputs held constant. This condition may not be met in a linear-programming framework because technological coefficients for activites are assumed to be at fixed ratios to one another. Thus, the increase in one unit of only one input requires the increase in other inputs in order to keep the ratio of coefficients fixed. Despite this deficiency, MVPs can provide information on the most likely resources to be expanded in order to increase the value of the objective function. The MVP of a resource is constant over the specific range, and the solution holds until other resources become limiting. At that point, another enterprise organization becomes optimal, and the MVP of the resource changes.

The MVPs indicate the productivity of resources on the farm. They show the amount of total farm income that can be increased by the utilization of the additional unit of the resource. Thus, they give information about the possible gains or losses in farm income that are possible through the acquisition of the scarce resource. The MVPs of slack resources are zero and positive for the limiting factors or constraint resources. The more limiting the resource, the higher its MVP. In order to be meaningful, therefore, the MVP of the resource should be compared to its cost of acquisition of its marginal-factor cost (MFC). It is profitable to acquire an additional unit of a resource if its MVP is greater than its acquisition cost. Maximum farm income can be obtained only when all MVPs of all resources are equal to their MFCs.

The MVPs of resources used in the production of cotton and maize in Models A_1 to A_4 are given in Table 6.3. For each model, there are two columns of MVPs. One column contains MVPs of resources used in the production of cotton and maize when the price for maize was Tsh 1.00 and the other when the price for maize was Tshs 2.50.

At the maize price of Tshs 1.00 or Tshs 2.50, land was in excess supply in Models A_1 to A_4, as shown by its zero MVP. However, farmers could not increase their incomes by using more land because they were constrained by other resources, particularly labor. The use of ox-drawn equipment or tractors did not bring enough land into use to make it a constraint on production.

Irrespective of which of the two maize prices was used, not one of Models A_1 to A_4 showed family labor constraints in August, September, March, and April. However, family labor in November and January was a

limiting factor in all models. In November, much labor was required to cultivate the land and/or to make ridges. The factor was also limiting in January, when weeding for cotton and maize required a great deal of labor to fight weeds that grow rapidly as a result of heavy rains.

The effect of partial mechanization on resource constraints was clearly shown when MVPs of family labor for Models A_1 and A_2 were compared, irrespective of which maize price was used. First, the use of ox-drawn equipment for land cultivation in Models A_2 and A_3 reduced labor demand in October, thus removing the constraint that was observed in Model A_1. Second, ox technology, by expanding the area under cultivation, increased the demand for labor during ridging, weeding, and harvesting. The analyses showed that the MVPs of family labor in November, December, January, February and May were higher in Model A_2 than in A_1. At the maize price of Tshs 2.50, for example, the MVPs of family labor in Model A_1 were Tshs 2.75, 1.08, 0.93, 1.12, and 0.95 respectively. The corresponding MVPs in Model A_2 were Tshs 2.87, 1.60, 1.28, 2.03, and 1.16. Apparently, ox plow cultivation aggravated the seasonal labor bottleneck.

Although no allowance was made in the model for selling farming labor, the wage rates for hired labor can be taken to reflect the family-labor opportunity cost. The wage rates in October, November, December, January, February, and May were Tshs 3.10, 3.25, 3.87, 4.13, 4.98, and Tshs 1.85. Thus, in any model, farmers could not increase their income by hiring more labor because MVPs were less than the MFCs for the months mentioned above.

The farmers could increase their income either by working extra hours or by organizing working parties. The latter alternative might not be possible. Labor from working parties was a constraint in October and November for Models A_1 and A_4 and in November for A_2 and A_3 (see Table 6.3). Since these months were the peak labor periods for farmers (the main source of this type of labor), working parties became very limited.

The MVP of an owned ox team was zero. No more of this resource could be used until more labor became available for weeding and harvesting, or until farmers were taught how to use ox-drawn equipment for farming operations other than land cultivation.

In October and November, operating captial was a constraint in all models when the price for maize was Tshs 2.50. The resource was more constraining in October for Models A_2 and A_3. With the expansion of land under cultivation, more cash expenses were made to pay for hired oxen technology (in the case of Model A_3), operating costs for the increased use of owned ox technology (in Model A_2), and expenditures on increased use of fertilizers and insecticides.

The MVPs of fertilizers and insecticides were equal to their prices. The MVP of TSP = MFC of TSP = Tshs 1.34; the MVP of SA = MFC of SA = Tshs 1.03; the MVP of Thiodan - its MFC = Tshs 13.34; and the MVP of DDT = its MFC - Tshs 5.06. It was not known, however, with existing fertilizer and insecticide prices and under existing input-output relationships, whether optimum use of these resources had been achieved. Data on production responses to these inputs were not available.

Optimal Organizations of the Participants' Representative Farms with Variable Product, Fertilizer, and Insecticide Prices, and Operating-Capital Levels for Early Cottón and Maize

The extent to which the optimal allocation of existing farm resources under the present state of technology and prices would increase the net farm income, change existing cropping patterns, and improve resource use was shown in the analyses of Models A_1 to A_4. It is necessary to explore the impact on Models A_1 to A_4 of variable-product prices, fertilizer and insecticide prices, and operating-capital level on: (1) net farm income; (2) cropping patterns; and (3) resource use. In Tables 6.4 to 6.15 and in the accompanying discussion, these changes are presented as Alternatives I, II and III. Alternative I represents increases in the relative prices of cotton and maize; Alternative II represents the increase in the prices of fertilizers and insecticides; Alternative III represents the increase in the level of operating capital.

Alternative I:

Changes in the Relative Prices of Early Cotton and Maize

As stated earlier in this chapter, the relative prices of cotton and maize were increased by zero percent and 80 percent; 25 percent and 80 percent; and 25 percent and 150 percent for cotton and maize respectively. These increases were in keeping with government price increases that ranged from zero percent between 1975-76 and 1976-77 to 25 percent between 1979-80 and 1980-81 for cotton and with market-price increases for maize (within Mwanza Region) that ranged from 80 percent to 150 percent above the government price between May and October 1980.

Although relative product prices were changed, input prices and level of operating capital remained unchanged.

Since there are three product-price changes, Alternative I was divided into three subalternatives. In Alternative Ia, produce prices of Tshs 3.20 for cotton and 1.80 for maize were used. In Alternative Ib, the prices of Tsh 4.00 for cotton and 1.80 for maize were used. In Alternative Ic, product prices of Tshs 4.00 for cotton and 2.50 for maize were used.

The changes in net farm income, cropping patterns, and resource use for those product-price changes are given in Tables 6.4 to 6.6.

As shown in Table 6.4, Alternative Ia led to a remarkable fall in hectarage planted in maize and a remarkable increase in cotton hectarage in Models A_1 to A_4. In Model A_1 the area planted in cotton increased from 1.65 to 2.01 hectares, whereas maize hectarage decreased from 1.30 in the base plan to 0.48 in the alternative plan. These represent an increase of 21.82 percent and a decrease of 63.07 percent in the areas planted in cotton and maize respectively. In Model A_2, the cotton area increased by 28.48 percent, whereas the maize area decreased by 55.47 percent. There was also an increase of 23.03 percent and a decrease of 56.06 percent in the areas of cotton and maize, respectively, for Model A_3. As in the base plan, the changes in Model A_4 were similar to those in A_4. The total land planted in the crops, however, declined in Models A_1 to A_4.

As a result of the changes in land use, the use of other resources also changed. In Model A_1, the decrease in cropped area led to a decrease in the use of labor; family labor declined by 10.07 percent, and

Table 6.4

Efficiency Measures for the Base Plans[a] and Changes in Relative Product Prices for Early Cotton and Maize for the Participants:

Alternative Ia

ITEM	UNIT	Base Plan for Model A_1	New Plan for A_1	% Change	Base Plan for Model A_2	New Plan for A_2	% Change	Base Plan for Model A_3	New Plan for A_3	% Change	Base Plan for Model A_4	New Plan for A_4	% Change
Net Farm Income (NFI)	Tshs	5538.46	4506.83	-18.63	5729.60	4981.28	-13.06	5614.93	4708.51	-16.14	5538.46	4506.83	-18.63
Land (Early Cotton)	Ha	1.65	2.01	+21.82	1.65	2.12	+28.48	1.65	2.03	+23.03	1.65	2.01	+21.82
Land (Maize)	Ha	1.30	0.48	-63.07	1.37	0.61	-55.47	1.32	0.58	-56.06	1.30	0.48	-63.07
Total Land	Ha	2.95	2.49	-15.59	3.02	2.73	- 9.6	2.97	2.61	-12.12	2.95	2.49	-15.59
Family Labor	Hrs	3684.99	3313.95	-10.07	3761.99	3633.37	- 3.42	3695.16	3518.95	- 4.76	3684.99	3313.95	-10.07
Hired Labor	Hrs	104.53	3.57	-96.58	104.53	3.57	-96.58	104.53	3.57	-96.58	104.53	3.57	-96.58
Working Party	Hrs	652.72	380.15	-41.75	718.06	423.38	-41.04	687.31	391.43	-43.05	652.72	380.15	-41.75
Total Labor	Hrs	4442.24	3697.67	-16.76	4584.58	4060.32	-11.43	4487.00	3913.95	-12.77	4442.24	3697.67	-16.76
Ox Team (Owned)	Ox Hrs	-	-	-	89.98	81.35	- 9.59	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-		46.82	39.14	-16.40	-	-	-
Tractor (Hired)	Trc Hr	-	-	-	-	-		-	-	-	0	0	0
Operating Capital	Tshs	1026.74	739.52	-27.97	1241.35	917.40	-26.09	1305.50	864.07	-33.75	1026.74	739.52	-27.97
NFI/Ha	Tshs	1877.44	1809.96	- 3.59	1897.21	1824.65	- 3.82	1890.55	1804.02	- 4.57	1877.44	1809.96	- 3.59
NFI/Hr Unpd. Labor	Tshs	1.50	1.36	- 9.33	1.52	1.37	- 9.06	1.51	1.34	-11.26	1.50	1.36	- 9.33
NFI/Operating Cap.	Tshs	5.39	6.09	+12.98	4.62	5.43	+17.53	4.30	5.45	-26.72	3.39	6.09	+12.98

[a] The base plans are included in this and subsequent tables to facilitate comparison.

hired labor and labor from working parties declined by 96.58 percent and 41.75 percent respectively. Total labor use declined by 16.76 percent.

In Model A_2, the use of family labor decreased by 3.42 percent, that of hired labor by 96.58 percent, and that of labor from working parties by 41.04 percent. In all, labor use declined by 11.43 percent. Total labor use in Model A_3 declined by 12.77 percent. Of this, family labor decreased by 4.76 percent, hired labor by 96.58 percent, and working parties by 43.05 percent.

The use of ox-drawn equipment in Models A_2 and A_3 also declined. Although in Model A_2 the use of owned ox-drawn equipment declined by 9.59 percent, that of hired ox-drawn equipment declined by 16.40 percent. The decline in the use of farm resources that require cash expenses, such as hired labor, working parties, ox technology, and so on, led to a fall in the use of operating capital. It fell by 27.97 percent in Model A_1, by 26.09 in Model A_2, and by 33.75 percent in Model A_3.

The changes in net farm income were also remarkable. The estimated net farm income in Model A_1 decreased from Tshs 5538.46 in the base plan to Tshs 4506.83 in the alternative plan; this represented a fall of 18.63 percent. Consequently, the net farm income per hectare declined by 3.59 percent. This small decline in return to land, despite a big fall in net farm income, was also due to a decline in cropped land. The return to unpaid labor (family labor) decreased from Tshs 1.50 to Tshs 1.36, a 9.33 percent fall. Finally, net farm income per a unit of operating capital increased by 12.98 percent.

In Model A_2, the net farm income was estimated to be Tshs 4981.28, compared to Tshs 5729.60 in the base plan. This represented a decline

of 13.06 percent. The return to land was Tshs 1824.65. This was a decline of 3.82 percent from that in the base plan. Although net farm income per unit of unpaid labor declined from Tsh 1.52 to 1.37, a 9.06 percent fall, that per unit of operating capital increased by 17.53 percent.

The estimated net farm income for Model A_3 decreased from Tshs 5614.93 in the base plan to Tshs 4708.51 in the alternative plan. This represented a 16.14 percent fall. As a result, net farm income per hectare declined by 4.57 percent, the return to unpaid labor declined by 11.26 percent, and the return to a unit of operating capital increased by 26.72 percent.

In Alternative I_b, the official product prices increased by 25 percent for cotton and 80 percent for maize. As in the previous case, there were substantial changes in areas planted with each crop, use of labor, and other resources, as well as in net farm incomes for Models A_1, A_2, A_3, and A_4. The results are presented in Table 6.5.

In Model A_1, the cotton area increased by 25.45 percent, whereas the area planted in maize decreased by 65.38 percent. The same changes were observed in Model A_4. Even higher increases in the area planted in cotton were achieved in Models A_2 and A_3. In the former, the cotton area increased by 33.94 percent and in the latter by 27.27 percent. Although the area planted in maize declined by 59.12 percent in Model A_2, that in Model A_3 declined by 59.84 percent. Furthermore, in each model, total land cropped was less than that in their respective base plans.

Table 6.5

Efficiency Measures for the Base Plans and Changes in Relative Product Prices for Early Cotton and Maize for Participants: Alternative Ib

ITEM	UNIT	Base Plan for Model A_1	New Plan for A_1	% Change	Base Plan for Model A_2	New Plan for A_2	% Change	Base Plan for Model A_3	New Plan for A_3	% Change	Base Plan for Model A_4	New Plan for A_4	% Change
Net Farm Income (NFI)	Tshs	5538.46	5713.12	+ 3.15	5729.60	6267.51	+ 9.38	5614.93	5921.41	+ 5.46	5538.46	5713.12	+ 3.15
Land (Early Cotton)	Ha	1.65	2.07	+25.45	1.65	2.21	+33.94	1.65	2.10	+27.27	1.65	2.07	+25.45
Land (Maize)	Ha	1.30	0.45	-65.38	1.37	0.56	-59.12	1.32	0.53	-59.84	1.30	0.45	-65.38
Total Land	Ha	2.95	2.52	-14.57	3.02	2.77	- 8.28	2.97	2.63	+11.45	2.95	2.52	-14.57
Family Labor	Hrs	3684.99	3427.61	- 6.98	3761.99	3706.96	- 1.46	3695.16	3581.49	- 3.08	3684.99	3427.61	- 6.98
Hired Labor	Hrs	104.53	3.57	-96.58	104.53	3.57	-96.58	104.53	3.57	-96.58	104.53	3.57	-96.58
Working Party	Hrs	652.72	398.19	-38.99	718.06	441.13	-38.56	687.31	408.40	-40.57	652.72	398.19	-38.99
Total Labor	Hrs	4442.24	3829.37	-13.79	4584.58	4151.66	- 9.44	4487.00	3993.46	-10.99	4442.24	3829.37	-13.79
Ox Team (Owned)	Ox Hrs	-	-	-	89.98	82.54	- 8.27	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	46.82	40.68	-13.11	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	1026.74	783.15	-23.72	1241.35	985.09	-20.64	1304.40	896.87	-31.24	1026.74	783.15	-23.72
NFI/Ha	Tshs	1877.44	2267.11	+20.75	1897.21	2262.64	+19.26	1890.55	2251.49	+19.09	1877.44	2267.11	+20.75
NFI/Hr of Unpd Labor	Tshs	1.50	1.67	+11.31	1.52	1.69	+11.18	1.51	1.65	+ 9.27	1.50	1.65	+11.31
NFI/Operating Capital	Tshs	5.39	7.29	+35.34	4.62	6.36	+37.71	4.30	6.60	+53.48	3.39	7.29	+35.34

The reduction in cropped areas resulted in less use of other resources. In Models A_1 and A_4, family labor, hired labor, and labor from working parties decreased by 6.98 percent, 96.58 percent, and 38.99 percent respectively; in Model A_2 these changes in labor use decreased by 1.46 percent, 96.58 percent, and 38.56 percent; in Model A_3 family labor decreased by 3.08 percent, hired labor by 96.58 percent and working parties by 40.57 percent. The use of ox-drawn equipment declined by 8.27 percent in Model A_2 and by 13.11 percent in Model A_3. Since the use of farm resources that require operating capital to acquire them declined, the use of operating capital fell by 23.72 percent in Models A_1 and A_4, by 20.64 percent in A_2, and by 31.24 percent in A_3.

Unlike Alternative Ia, in which net farm incomes in Models A_1 to A_4 declined remarkably from those in their respective base plans, net farm incomes in Alternative Ib increased. The estimated net farm income in Models A_1 and A_4 increased from Tshs 5538.46 to Tshs 5713.12, or an increase of 3.15 percent. As a result, the return to land increased by 20.75 percent, the return to unpaid labor increased by 11.31 percent, and the return to a unit of operating capital increased by 35.34 percent. In Model A_2, the net farm income was estimated to be Tshs 6267.51 compared to Tshs 5729.60 in the base plan; this was an increase 9.38 percent. As a result of this increase and a decrease in the use of farm resources, net farm income per hectare increased by 19.26 percent, return to unpaid labor increased by 11.18 percent, and return to a unit of operating capital by 37.71 percent. The estimated net farm income for Model A_3 came to Tshs 5921.41 compared to Tshs 5614.93

in the base plan. This represented an increase of 5.46 percent. In turn, the return per hectare of land, the return to unpaid labor, and the return per unit of operating capital increased by 19.09 percent, 9.27 percent, and 53.48 percent.

The results for Alternative Ic, as shown in Table 6.6, were also substantial. In Models A_1 and A_4, the cotton area increased by 2.42 percent whereas that planted in maize fell by 4.62 percent. In Model A_2, the area planted in cotton increased by 3.64 and that planted in maize decreased by 6.57 percent. Although the cotton area in Model A_3 increase by only 1.82 percent, the area planted in maize declined by 4.54 percent. The results also showed that total cultivated land declined in each model.

The above changes in land allocation resulted also in notable changes in the use of other resources. In Model A_1, family labor and working parties increased by 0.56 percent and 7.25 percent respectively, whereas hired labor declined by 10.87 percent. Total labor used, however, increased by 1.26 percent. The use of family labor and working parties in Model A_2 increased by 1.64 percent and 0.73 percent respectively. There was no change in the employment of hired labor. Total labor use increased by 1.46 percent. Despite a decline in total cultivated land, labor use in these two models increased. The reason lay in the increase in the cotton area. Cotton demands more labor per hectare than does maize. Thus, the declines in the maize area of 4.62 percent for Model A_1 and 6.57 percent for Model A_2 did not release enough labor to meet the demands of an increased cotton area. In Model A_3, however, the decline of 0.06 hectares in the maize area was more than sufficient to meet the demand for labor by

Table 6.6

Efficiency Measures for the Base Plans and Changes in Relative Product Prices for Early Cotton and Maize for Participants: Alternative Ic

ITEM	UNIT	Base Plan for Model A_1	New Plan for A_1	% Change	Base Plan for Model A_2	New Plan for A_2	% Change	Base Plan for Model A_3	New Plan for A_3	% Change	Base Plan for Model A_4	New Plan for A_4	% Change
Net Farm Income (NFI)	Tshs	5538.46	6458.78	+16.62	5729.60	6601.16	+15.21	5614.93	6475.69	+13.55	5538.46	6458.78	+16.62
Land (Early Cotton)	Ha	1.65	1.69	+ 2.42	1.65	1.71	+ 3.64	1.65	1.68	+ 1.82	1.65	1.69	+ 2.42
Land (Maize)	Ha	1.30	1.24	- 4.62	1.37	1.28	- 6.57	1.32	1.26	- 4.54	1.30	1.24	- 4.62
Total Land	Ha	2.95	2.93	- 0.68	3.02	2.99	+ 0.99	2.97	2.94	- 1.01	2.95	2.93	- 0.68
Family Labor	Hrs	3684.99	3705.81	+ 0.56	3761.99	3823.80	+ 1.64	3695.16	3677.04	- 0.49	3684.99	3705.81	+ 0.56
Hired Labor	Hrs	104.53	93.16	-10.87	104.53	104.53	0	104.53	91.96	-12.03	104.53	93.16	-10.87
Working Party	Hrs	652.72	699.38	+ 7.25	718.06	718.06	+ 0.73	687.31	670.88	- 2.39	652.72	699.38	+ 7.25
Total Labor	Hrs	4442.24	4498.35	+ 1.26	4584.58	4584.58	+ 1.46	4487.00	4439.88	- 1.05	4442.24	4498.35	+ 1.26
Ox Team (Owned)	Ox Hrs	-	-	-	89.98	89.10	- 0.97	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	46.82	46.82	0	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	1026.74	1092.69	+ 6.52	1241.35	1285.10	+ 3.50	1304.40	1238.22	+ 5.07	1026.74	1092.69	+ 6.52
NFI/Ha	Tshs	1877.44	2204.36	+17.41	1897.21	2207.74	+16.36	1890.55	2202.61	+16.51	1877.44	2204.36	+17.41
NFI/Hr of Unpd Labor	Tshs	1.50	1.74	+16.00	1.52	1.73	+13.82	1.51	1.76	+16.56	1.50	1.74	+16.00
NFI/Operating Capital	Tshs	5.39	5.97	+ 9.66	4.62	5.14	+11.18	4.30	5.23	+21.62	3.39	5.91	+ 9.66

cotton for which the area increased by 0.03 hectares. Thus, family labor declined by 0.49 percent, hired labor by 12.03 percent, and labor from working parties by 2.39 percent. Labor use declined by 1.05 percent. The use of owned ox-drawn equipment in Model A_2 declined by 0.97 percent, whereas that of hired ox-drawn equipment in Model A_3 did not change. Operating capital increased in all models; these increases were 5.62 percent, 3.50 percent, 5.07 percent and 5.62 percent for Models A_1, A_2, A_3, and A_4.

Increases in net farm income were much higher in Alternative Ic than in Ib; better product prices and more area cropped led to the differences in net farm income. In Models A_1 and A_4, net farm income came to Tshs 6458.78 compared to Tshs 5538.46 in the base plan. This was a 16.62 percent increase. As a result of this change and a decline in the area cultivated, net farm income per hectare increased from Tshs 1877.44 in the base plan to Tshs 2204.36 in the alternative plan. This represented an increase of 17.41 percent. Return to unpaid labor increased from Tsh 1.50 to 1.74 or a 16 percent increase. Despite an increase in operating capital, the return per unit of operating capital increased from Tshs 5.39 to Tshs 5.97, an increase of 9.66 percent.

The estimated net farm income in Model A_2 was Tshs 6601.16. This was an increase of 15.21 percent from Tshs 5729.60 in the base plan. Net farm income increased from Tshs 1897.21 in the base plan to Tshs 2207.74 in the alternative plan. This represented an increase of 16.36 percent. Whereas return to unpaid labor increased by 13.82 percent, from Tsh 1.52 to Tsh 1.73, the return to a unit of operating capital increased from Tshs 4.62 to Tshs 5.14, an 11.18 percent increase.

In Model A_3, net farm income increased from Tshs 5614.93 in the base plan to Tshs 6475.69 in the new plan. As a result of this change and changes in the use of farm resources, there were remarkable changes in return to land, unpaid labor, and operating capital. The return to a hectare of land increased from Tshs 1890.55 to 2202.61, an increase of 16.51 percent. Although the return to unpaid labor increased by 16.56 percent, from Tshs 1.51 to Tshs 1.76, the return to a unit of operating capital increased from Tshs 4.30 to Tshs 5.23, a 21.62 percent increase.

These results provided important insights into farmers' responses to changes in product prices. It was quite clear from the results in Alternative Ia that maize was less competitive than cotton. Although the area planted in maize declined remarkably, that planted in cotton increased substantially. Further, net farm income was lower than that in the base plan, and so were the returns to land, to unpaid labor, and to a unit of operating capital. The employment of owned ox-drawn equipment (Model A_2) declined by a smaller percentage than that of hired ox-drawn equipment (Model A_3).

In Alternative Ib, maize became even less competitive in all models. The area planted in maize was smaller than that in Alternative Ia. The amount produced was just enough to meet household consumption needs. On the other hand, the cotton area increased by a larger percentage. And, as in Alternative Ia, the decline in the employment of hired ox-drawn equipment was larger than that of owned ox-drawn equipment.

Alternative Ic showed better results. Maize was more competitive than it was in the other two alternatives. Food produced in this alternative was more than double that produced in the other two alternatives. In addition, net farm income in each model was higher than the respective incomes in the base plans.

Apart from the insights related to each alternative, there were general observations to be drawn from the results. First, the current official price for maize was too low to make maize competitive with cotton. Even an increase of 80 percent (from Tsh 1.00 to Tsh 1.80), although keeping the price for cotton at Tshs 3.20, did not lead to a substantial change in the area planted in maize or, consequently, to maize output. The black market of Tshs 2.50 seemed to be more influential in farmers' decision-making processes. Second, the results showed that farmers were sensitive to relative produce prices. Given the importance of both crops to the national economy, it was necessary to carefully consider the impact of changes in product prices on farmers' resource-allocation decisions and their eventual impact on output. Third, the use of ox-drawn equipment seemed to be profitable, despite its limited use. The results showed that in each alternative, Model A_2 produced the highest net farm income followed by Model A_3, and A_1 (or A_4). Tractor hiring (Model A_4) was not profitable in any alternative. Finally, land cultivated was less than the amount available. The main reason was lack of enough resources--especially labor to farm additional land. The availability of ox-drawn equipment in Models A_2 and A_3 did not utilize all land because the technology was limited to land cultivation; this left ridging, weeding, and harvesting operations to be done by labor.

Marginal-Value Products (MVPs in Tshs) of Resources Under Alternative I

The marginal-value products of resources for the three alternative relative product prices are presented in Tables 6.7 to 6.9. Under Alternative Ia (see Table 6.7), the MVP of land was zero in each model. This implied that land was in excess supply. The same conclusion was reached with respect to family labor in August and September. As a result of a decline in land cultivated in each model, monthly labor requirements for the two crops declined. Thus, in Models A_1 and A_4, MVPs for family labor in October to February were lower than those in the base plans. The MVP of family labor in May dropped from 0.95 Tshs to zero; the reason for this was the substantial decline in the area planted in maize, the crop that needs more labor in May since this is the harvesting period. The MVP of family labor in June was Tshs 2.13 compared to zero in the base plan. This was a result of the increase in the area planted in cotton, which demands more labor for harvesting during June.

Other unstable changes in Models A_1 and A_4 were the MVPs of working parties and operating capital. In October and November, the MVP of working-party labor declined from those in the base plan; the changes were from MVPs of Tshs 1.37 to 0.98 in October, and from Tshs 1.66 to 1.03 in November. The MVPs of operating capital became zero in the new plan. Again, these changes resulted from the decline in land cultivated, which in turn led to a decline in the use of labor, fertilizer, and insecticides.

Table 6.7

Marginal-Value Products (MVPs in Tshs) of Resources for Models A_1 to A_4 for Participants: Alternative I_a

RESOURCE	UNIT	MODEL A_1		MODEL A_2		MODEL A_3		MODEL A_4	
		BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN
FL Oct.	Hr	2.99	1.73	0	0	0	0	2.99	1.73
FL Nov.	Hr	2.75	1.18	2.87	2.30	2.59	1.47	2.75	1.18
FL Dec.	Hr	1.08	0.65	1.60	1.24	1.40	1.02	1.08	0.65
FL Jan.	Hr	0.93	0.41	1.28	0.89	1.19	0.77	0.93	0.41
FL Feb.	Hr	1.12	0.96	2.03	1.91	2.21	1.60	1.12	0.96
FL May	Hr	0.95	0	1.16	0.71	1.76	0.56	0.95	0
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	13.34	5.06	13.34	5.06	13.34	5.06	13.34
OC Oct.	Tshs	0.49	0	0.81	0	0.98	0	0.49	0
OC Nov.	Tshs	0.49	0	0.20	0	0.07	0	0.49	0
WP LMT Oct.	Hr	1.37	0.98	0	0	0	0	1.37	0.98
WP LMT Nov.	Hr	1.66	1.03	1.79	1.11	1.52	1.38	1.66	1.03

The changes in MVPs of resources for Models A_2 and A_3 were not very different from those for Models A_1 and A_4. The MVPs of family labor in November to February and May were lower than their corresponding MVPs in the base plans. However, the MVPs of family labor in June were Tshs 2.98 and Tshs 2.35 compared to the MVPs of zero under the base plans in Models A_2 and A_3 respectively. In addition, operating capital, which, under the base plans, was a constraint in October and November, was in excess in the new plans.

In summary, the reduction in demand for labor and other inputs as a result of the decline in the area planted in maize more than offset the increased demand for these resources as a result of an increased cotton area. This explained the marginal decline in MVPs of most farm resources. The only exception was the MVP of family labor in June, which increased substantially because of the increased demand for labor to harvest the expanded cotton area.

The MVPs of resources for Alternative Ib are presented in Table 6.8. As with Alternative Ia, the MVP of land was zero in each model, as were the MVPs of family labor in August and September. The changes in the MVPs of other resources followed the same pattern as those in Alternative Ia; MVPs of family and working-party labor were slightly lower than their corresponding MVPs in the base plans for each model. There were two exceptions to this general conclusion. One was that the MVP of family labor in May was zero in each model because there was much less land cultivated for maize, causing much less demand for labor during harvesting. The other exception was that the MVPs of

Table 6.8

Marginal-Value Products (MVPs in Tshs) of Resources for Model A_1 to A_4 for Participants: Alternative I_b

RESOURCE	UNIT	MODEL A_1		MODEL A_2		MODEL A_3		MODEL A_4	
		BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN
FL Oct.	Hr	2.99	1.84	0	0	0	0	2.99	1.84
FL Nov.	Hr	2.75	1.33	2.87	2.14	2.59	1.72	2.75	1.33
FL Dec.	Hr	1.08	0.90	1.60	1.09	1.40	0.97	1.08	0.90
FL Jan.	Hr	0.93	0.67	1.28	0.88	1.19	0.75	0.93	0.67
FL Feb.	Hr	1.12	1.05	2.03	1.53	2.21	1.29	1.12	1.05
FL May	Hr	0.95	0	1.16	0	1.76	0	0.95	0
FL June	Hr	0	7.71	0	8.22	0	7.88	0	7.71
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
OC Oct.	Tshs	0.49	0	0.81	0	0.98	0	0.49	0
OC Nov.	Tshs	0.49	0	0.20	0	0.07	0	0.49	0
WP LMT Oct.	Hr	1.37	1.16	0	0	0	0	1.37	1.16
WP LMT Nov.	Hr	1.66	1.39	1.79	1.57	1.52	0.63	1.66	1.39
WP LMT June	Hr	0	0.85	0	2.39	0	1.24	0	0.85

family labor in June increased tremendously in the model. From zero MVPs in the base plans, the new MVPs were Tshs 7.71 for Models A_1 and A_4, Tshs 8.22 for A_2, and Tshs 7.88 for A_3. The reason was that the area planted in cotton had increased to even more than it was in Ia resulting in more demand for labor during harvesting. The changes in the MVPs of family labor in June were accompanied by changes in the MVPs of working-party labor, for which the value in the base plans was zero. The new MVPs of this resource were Tshs 0.85 for Models A_1 and A_4, Tshs 2.39 for Model A_2, and Tshs 1.24 for Model A_3.

The MVPs of resources in Alternative Ic, as shown in Table 6.9, were generally lower but closer to their respective MVPs in the base plans than were those in Alternative Ia or Ib. The reason was that the areas planted in maize and cotton were too different from those in the base plans. The most notable changes were in the MVPs of November and December for family labor in Model A_2 and the MVPs of October and November for operating capital in all models. In Model A_2, the MVPs of family labor in October (Tshs 2.90) and November (Tsh 1.68) were slightly higher than their respective MVPs in the base plans. Because of the expanded cotton area, more labor for ridging and planting was required than the labor released by the reduction in the maize area. In all models, the MVPs of operating capital in October and November were higher than their corresponding MVPs in the base plans. The increases in MVP may have resulted from an increase in demand for resources such as fertilizer and insecticides by the expanded area planted in cotton. This demand could not be met

Table 6.9

Marginal-Value Products (MVPs in Tshs) of Resources for Models A_1 to A_4 for Participants: Alternative I_c

RESOURCE	UNIT	MODEL A_1		MODEL A_2		MODEL A_3		MODEL A_4	
		BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN
FL Oct.	Hr	2.99	2.92	0	0	0	0	2.99	2.92
FL Nov.	Hr	2.75	2.64	2.87	2.90	2.59	2.51	2.75	2.64
FL Dec.	Hr	1.08	1.01	1.60	1.68	1.40	1.37	1.08	1.01
FL Jan.	Hr	0.93	0.80	1.28	1.16	1.19	1.06	0.93	0.80
FL Feb.	Hr	1.12	1.04	2.03	2.00	2.21	2.13	1.12	1.04
FL May	Hr	0.95	0.86	1.16	0.74	1.76	1.62	0.95	0.86
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
OC Oct.	Tshs	0.49	0.62	0.81	0.82	0.98	0.87	0.49	0.62
OC Nov.	Tshs	0.49	0.55	0.20	0.26	0.07	0.12	0.49	0.55
WP LMT Oct.	Hr	1.37	1.07	0	0	0	0	1.37	1.07
WP LMT Nov.	Hr	1.66	1.23	1.79	1.65	1.52	1.17	1.66	1.23

by the release of operating capital from the reduced maize hectarage, since cotton required more of these inputs per hectare than maize did. The reduction in working-party labor, as indicated by the fall of MVPs for this resource, released operating capital that was used to help meet the demand for other resources.

In summary, as shown by the results, the main limiting factor for increasing production was labor, especially during the peak seasons discussed in Chapter II. It is possible that if farmers were paid higher prices than those discussed, they would work extra hours and thus release family labor constraints in the optimal plan. It is most unlikely, however, that the government would increase prices of cotton and maize beyond the ranges discussed in this study. Price increases in the past ten years or so have not shown any indication of this happening. Nor was there any indication that the black market price for maize would increase by a big margin from the current price of Tshs 2.50 per kilogram; if this happened due to forces of supply and demand, consumers would shift their demand to other food items such as rice, sorghum, and cassava and eventually push down the price of maize.

Alternative II: Increases in the Prices of Fertilizers and Insecticides

The existing fertilizer and insecticide prices were subsidized by the World Bank and/or by the government. Eventually, however, the farmers would bear the full costs of these inputs. In the following discussion, unsubsidized prices are used in order to show their impact

on net farm income, cropping patterns, and resource use. In Tables 6.10 and 6.11, the results of the analysis are shown.

Increased fertilizer and insecticide prices reduced the area of maize and cotton in all four models. In Models A_1 and A_4, the cotton area decreased from 1.65 hectares to 1.53 hectares, a 7.27 percent decline, whereas the area planted in maize decreased from 1.30 hectares to 1.21 hectares, a decline of 6.92 percent. As a result of these changes, net farm income came to Tshs 5121.97 compared to Tshs 5538.46 in the base plan.

Reduction in the total area cultivated led to a decline in the employment of labor. Family labor decreased by 4.79 percent, hired labor by 96.58 percent, and labor from working parties by 31.09 percent. In all, use of labor decreased from 4442.24 man hours in the base plans to 3961.43 man hours in the new plans. This represented a 10.82 percent decrease. In addition, the use of operating capital decreased from Tshs 1026.74 to Tshs 993.56, a reduction of 3.23 percent. This resulted from the reduced use of fertilizers, insecticides, hired labor, and labor from working parties, all of which fell because of a decrease in cotton and maize areas.

The decline in net farm income and in levels of the use of resources led to the fall in returns to land, unpaid labor, and a unit of operating capital. The return per hectare of land was Tshs 1869.32 computed to Tshs 1877.44 in the base plan, a decrease of 0.43 percent. And although the net average return per man hour of unpaid labor decreased from Tsh 1.50 to Tsh 1.46, a decline of 2.67 percent, the net return to a unit of operating capital decreased from Tshs 5.39 to Tshs 5.16, representing a fall of 4.26 percent.

Table 6.10

Efficiency Measures for the Base Plans and Increases in Fertilizer and Insecticide Prices for Early Cotton and Maize for Participants

ITEM	UNIT	Base Plan for Model A_1	New Plan for A_1	% Change	Base Plan for Model A_2	New Plan for A_2	% Change	Base Plan for Model A_3	New Plan for A_3	% Change	Base Plan for Model A_4	New Plan for A_4	% Change
Net Farm Income (NFI)	Tshs	5538.46	5121.97	- 7.52	5729.60	4996.43	-12.79	5614.93	5121.97	- 8.78	5538.46	5121.96	- 7.52
Land (Early Cotton)	Ha	1.65	1.53	- 7.27	1.65	1.51	- 8.48	1.65	1.53	- 7.27	1.65	1.53	- 7.27
Land (Maize)	Ha	1.30	1.21	- 6.92	1.37	1.17	-14.59	1.32	1.21	- 8.33	1.30	1.21	- 6.92
Total Land	Ha	2.95	2.74	- 7.11	3.02	2.68	-11.26	2.97	2.74	- 7.74	2.95	2.74	- 7.11
Family Labor	Hrs	3684.99	3508.12	- 4.79	3761.99	3458.09	- 8.07	3695.16	3508.12	- 5.06	3684.99	3508.12	- 4.79
Hired Labor	Hrs	104.53	3.57	-96.58	104.53	3.57	-96.58	104.53	3.57	-96.58	104.53	3.57	-96.58
Working Party	Hrs	652.72	449.74	-31.09	718.06	411.26	-42.73	687.31	449.74	-34.56	652.72	449.74	-31.09
Total Labor	Hrs	4442.24	3961.43	-10.82	4584.58	3873.92	-15.50	4487.00	3961.43	-11.71	4442.24	3961.43	-10.82
Ox Team (Owned)	Ox Hrs	-	-	-	89.98	78.86	-12.36	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	46.82	0	-100	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	1026.74	993.56	- 3.23	1241.35	966.45	-22.14	1304.40	993.56	-23.80	1026.74	993.56	- 3.23
NFI/Ha	Tshs	1877.44	1869.32	- 0.43	1897.21	1864.21	- 1.73	1890.55	1869.32	- 1.12	1877.44	1869.32	- 0.43
NFI/Hr of Unpd Labor	Tshs	1.50	1.46	- 2.67	1.52	1.52	- 5.26	1.51	1.46	- 3.97	1.50	1.46	- 2.67
NFI/Operating Capital	Tshs	5.39	5.16	- 4.26	4.62	5.17	+11.90	4.30	5.16	+26.98	3.39	5.16	- 4.26

The results in Model A_2 were the worst. Although cotton area decreased from 1.64 to 1.51 hectares, the area planted in maize decreased from 1.37 to 1.17 hectares. Consequently, net farm income came to Tshs 4996.43, compared to Tshs 5729.60; this represented a 12.79 percent reduction. Employment of family labor, hired labor, and labor from working parties declined by 8.07 percent, 96.58 percent, and 42.73 percent respectively. The use of owned ox-drawn equipment decreased from 89.98 to 78.86 ox hours, a 12.36 percent fall. The reduction in the employment of hired labor, labor from working parties, as well as the decrease in the amount of fertilizers and insecticides used decreased operating capital from Tshs 1241.35 in the base plan to Tshs 966.46 in the new plan; this was a 22.14 percent decline.

With the exception of the return to a unit of operating capital, which increased from Tshs 4.62 to 5.17, an 11.90 percent increase, the changes in the return to land and to unpaid family labor followed the same pattern as they did in Models A_1 and A_4. The net farm income per hectare declined from Tshs 1897.21 in the base plan to Tshs 1864.34 in the new plan. This represented a decline of 1.73 percent. The return to unpaid labor came to Tshs 1.44 compared to Tshs 1.52 in the base plan, a decrease of 5.26 percent.

In Model A_3, the increase in fertilizer and insecticide prices resulted in more or less the same changes as in Model A_1. The area planted in cotton was 1.53 hectares, a decrease of 7.27 percent from 1.65 hectares in the base plan. The area planted in maize decreased from 1.32 hectares in the base plan to 1.21 hectares in the new plan, a decrease of 8.33 percent. The reduction in cultivated land led to a reduction in the use of other resources. Family labor declined from 3695.16 to 3508.12 man hours, a 5.06 percent decrease. The employment of hired labor and labor from working parties declined by 96.58 percent and 42.73 percent respectively. In addition, no ox-drawn equipment was hired compared to 46.82 ox hours hired in the base plan. The reduction in land cultivated meant that the demand for labor decreased and that, given no changes in the supply of labor, there was enough labor for all farm operations. Hiring of ox-drawn equipment become unprofitable. Operating capital fell substantially; whereas it was Tshs 1304.40 in the base plan, in the new plan it came to Tshs 993.56, a decline of 23.80 percent.

As a result of these changes, net farm income decreased from Tshs 5614.93 in the base plan to Tshs 5121.97 in the new plan. Further, net farm income per hectare decreased from Tshs 1890.55 to Tshs 1869.32, a reduction of 1.12 percent; the return to unpaid labor decreased from Tshs 1.51 to Tshs 1.46, a 3.97 percent decrease. The only increase was realized in the return to a unit of operating capital; it increased from Tshs 4.30 to 5.16, an increase of 26.98 percent.

Marginal-Value Products (MVPs in Tshs) of Resources Under Alternative II

The MVPs of resources under Alternative II are shown in Table 6.11. The MVPs of most resources in all four models were either equal to or lower than their corresponding MVPs in the base plans. This was especially true with land, family labor, hired labor, labor from working parties, ox-drawn equipment, and operating capital from December to June.

Table 6.11

Marginal-Value Products (MVPs in Tshs) of Resources for Early Cotton and Maize for Participants: Alternative II

RESOURCE	UNIT	MODEL A_1		MODEL A_2		MODEL A_3		MODEL A_4	
		BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN
FL Oct.	Hr	2.99	2.13	0	0	0	2.13	2.99	2.13
FL Nov.	Hr	2.75	2.01	2.87	0.69	2.59	2.01	2.75	2.01
FL Dec.	Hr	1.08	0.67	1.60	0.81	1.40	0.67	1.08	0.67
FL Jan.	Hr	0.93	0.84	1.28	1.05	1.19	0.84	0.93	0.84
FL Feb.	Hr	1.12	0.86	2.03	1.76	2.21	0.86	1.12	0.86
FL May	Hr	0.95	0.29	1.16	1.11	1.76	0.29	0.95	0.29
TSP	Kg	1.34	1.92	1.34	1.92	1.34	1.92	1.34	1.92
SA	Kg	1.03	1.73	1.03	1.73	1.03	1.73	1.03	1.73
THDN	Tshs	13.34	26.68	13.34	26.68	13.34	26.68	13.34	26.68
DDT	Tshs	5.06	25.30	5.06	25.30	5.06	25.30	5.06	25.30
OC Oct.	Tshs	0.49	1.26	0.81	1.75	0.98	1.64	0.49	1.26
OC Nov.	Tshs	0.49	1.53	0.20	1.17	0.07	1.10	0.49	1.53
WP LMT Oct.	Hr	1.37	0.85	0	0	0	0	1.37	0.85
WP LMT Nov.	Hr	1.66	1.02	1.79	0	1.52	0	1.66	1.02

The MVP of land remained zero in all models, and so were the MVPs of family labor in August, September, March, April and June. In the other months, the MVPs of family labor were lower than those in the base plans. The MVPs of working party labor in October and November also declined. In Models A_2 and A_3, the MVPs declined from Tshs 1.37 to 0.85 in October and from Tshs 1.66 to 1.02 in November. The MVPs of TSP, SA, Thiodan, and DDT were higher than their corresponding MVPs in the base plans. However, the difference in the two plans lay in the different prices used for those inputs. In fact, the MVPs of these inputs were equal to their prices. As in the base plans, it was not known, with these input prices and under existing input-output relationships, whether the optimum use of these resources was achieved. Data on production responses to these inputs were not available.

The most notable changes in the MVPs of resources were those of operating capital. In each model, the MVPs of October and November operating capital were substantially higher than those in the base plans; in Models A_1 and A_4, the MVPs of operating capital increased from Tshs 0.49 to Tshs 1.26 in October and from Tshs 0.49 to 1.53 in November to Tshs 1.75 and 1.17 respectively. In Model A_3, the MVPs increased from Tshs 0.98 and 0.07 to Tshs 1.64 and 1.10 in October and November respectively. Undoubtedly, the increase in fertilizer and insecticide prices led to a higher demand for operating capital in those months during which these inputs were purchased. The reduction in area cultivated could not remove the constraints imposed by higher input prices.

Alternative III:

Increase in the Levels of Operating Capital

In the base plans, operating capital was a limiting factor in October and November. An assumption was made that farmers could increase the monthly levels of operating capital by 10 percent if given favorable prices and if their net farm incomes increased. The results of this change in operating capital are presented in Tables 6.12 and 6.13.

It is clear from Table 6.12 that the change in area cropped was remarkable in all models. Maize became more profitable than cotton. In Models A_1 and A_4, the area for cotton was reduced from 1.65 to 1.52 hectares. The area planted in maize increased from 1.30 to 1.47 hectares. The total area of land cultivated increased by 1.34 percent. The employment of other resources also increased; family labor increased by 0.56 percent; there was no change in the amount of labor hired; and although labor from working parties increased by 6.19 percent, operating capital increased 2.70 percent.

Consequently, net farm income increased from Tshs 5538.46 in the base plan to Tshs 5672.89, an increase of 2.43 percent. Because this percentage of increase was higher than those of area cultivated or family labor, the returns to land and to unpaid family labor increased by 1.06 percent and 2.00 percent respectively. The return to a unit of operating capital, however, declined from Tshs 5.39 to Tshs 5.38; the percentage of increase in the amount of operating capital was higher than the percentage of increase in net farm income.

Table 6.12

Efficiency Measures for the Base Plans and Increases in the Levels of Operating Capital for Early Cotton and Maize for Participants

ITEM	UNIT	Base Plan for Model A_1	New Plan for A_1	% Change	Base Plan for Model A_2	New Plan for A_2	% Change	Base Plan for Model A_3	New Plan for A_3	% Change	Base Plan for Model A_4	New Plan for A_4	% Change
Net Farm Income (NFI)	Tshs	5538.46	5672.89	+ 2.43	5729.60	5782.71	+ 0.92	5614.93	5693.04	+ 1.39	5538.46	5672.89	+ 2.43
Land (Early Cotton)	Ha	1.65	1.52	- 7.88	1.65	1.53	- 7.27	1.65	1.58	- 4.24	1.65	1.52	- 7.88
Land (Maize)	Ha	1.30	1.47	+13.08	1.37	1.51	+10.22	1.32	1.42	+ 7.57	1.30	1.47	+13.08
Total Land	Ha	2.95	2.99	+ 1.34	3.02	3.04	+ 0.66	2.97	3.00	+ 1.01	2.95	2.99	+ 1.34
Family Labor	Hrs	3684.99	3706.23	+ 0.56	3761.99	3797.04	+ 0.93	3695.16	3700.87	+ 0.15	3684.99	3706.23	+ 0.56
Hired Labor	Hrs	104.53	104.53	0	104.53	104.53	0	104.53	104.53	0	104.53	104.53	0
Working Party	Hrs	652.72	693.10	+ 6.19	718.06	729.09	+ 1.54	687.31	717.76	+ 2.97	652.72	693.10	+ 6.19
Total Labor	Hrs	4442.24	4503.86	+ 1.39	4584.58	4630.66	+ 1.01	4487.00	4523.16	+ 0.81	4442.24	4503.86	+ 1.39
Ox Team (Owned)	Ox Hrs	-	-	-	89.98	90.59	+ 0.68	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	46.82	47.65	+ 1.77	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	1026.74	1054.49	+ 2.70	1241.35	1250.35	+ 0.74	1304.40	1329.70	+ 1.94	1026.74	1054.49	+ 2.70
NFI/Ha	Tshs	1877.44	1897.28	+ 1.06	1897.21	1902.21	+ 0.26	1890.55	1897.68	+ 0.38	1877.44	1897.28	+ 1.06
NFI/Hr of Unpd Labor	Tshs	1.50	1.53	+ 2.00	1.52	1.56	+ 2.63	1.51	1.54	+ 1.98	1.50	1.53	+ 2.00
NFI/Operating Capital	Tshs	5.39	5.38	- 0.18	4.62	4.62	+ 0.21	4.30	4.28	- 0.46	3.39	5.38	- 0.18

Although the area planted in cotton decreased from 1.65 to 1.53 hectares in Model A_2, the area under maize increased from 1.37 to 1.51 hectares; these changes represented a decrease of 7.27 percent and an increase of 10.22 percent for cotton and maize respectively. The total area cultivated, however, increased from 3.02 to 3.04 hectares, an increase of 0.66 percent. As the total area cultivated increased, the employment of other resources also increased. Family labor increased by 0.93 percent; labor from working parties increased by 1.54 percent; use of owned ox-drawn equipment increased slightly by 0.68 percent; and operating capital increased by 0.74 percent.

The changes in the use of resources led to an increase in net farm income from Tshs 5729.60 in the base plan to Tshs 5782.71 in the new plan; this was an increase of 0.92 percent. In turn, the net farm income per hectare increased by 0.26 percent; the return to unpaid labor increased by 2.63 percent; and the return to a unit of operating capital increased by 0.21 percent.

In Model A_3, the cotton area decreased from 1.65 hectares in the base plan to 1.58 hectares in the new plan. The area planted in maize, on the other hand, increased from 1.32 to 1.42 hectares. These changes led to an increase of 0.03 hectares in the total area cultivated and to increases in the employment of other resources. The employment of family labor, labor from working parties, hired ox-drawn equipment, and operating capital increased by 0.15 percent, 2.97 percent, 1.77 percent, and 1.94 percent respectively.

The impact of the increased level of operating capital on net farm income was positive. From a net farm income of Tshs 5614.93, in the base plan, net farm income increased to Tshs 5693.04 in the new plan, an increase of 1.39 percent. This change, together with the changes in the employment of unpaid labor, area cultivated, and operating capital, led to an increase in return to unpaid labor and to land of 1.98 percent and 0.38 percent respectively, and to a decrease in return to a unit of operating capital by 0.46 percent.

Marginal Value Products (MVPs in Tshs) of Resources Under Alternative III

In Table 6.13, the MVPs of resources under Alternative III are shown. As in Alternative II, the MVPs of land; family labor in August, September, October (for Models A_2 and A_3), March, April, and June; owned ox-drawn equipment; operating capital in December to June; hired labor in October to May; and working parties in October (for Models A_2 and A_3), December, January, February, April and June were zero in all models and equal to their corresponding MVPs in their respective base plans. The MVPs of family labor in October (for Models A_1 and A_4) and in November, December, January, and February were lower in all four models than in the base plans. This reflected the fall in demand for labor mainly because of the decline in the cotton area; a 1 percent decrease in the cotton area released more labor than required by a 1 percent increase in the maize area. In May, however, the MVPs of family labor were higher than the corresponding MVPs in the base plans. As a result of the increase in the maize area, demand for labor for harvesting, which takes place in May, increased. This higher demand

Table 6.13

Marginal-Value Products (MVPs in Tshs) of Resources for Early Cotton and Maize for Participants: Alternative III

RESOURCE	UNIT	MODEL A_1		MODEL A_2		MODEL A_3		MODEL A_4	
		BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN	BASE PLAN	NEW PLAN
FL Oct.	Hr	2.99	2.59	0	0	0	0	2.99	2.59
FL Nov.	Hr	2.75	2.33	2.87	2.44	2.59	2.40	2.75	2.33
FL Dec.	Hr	1.08	0.97	1.60	1.26	1.40	1.12	1.08	0.97
FL Jan.	Hr	0.93	0.76	1.28	1.02	1.19	0.98	0.93	0.76
FL Feb.	Hr	1.12	1.55	2.03	2.32	2.21	2.06	1.12	1.55
FL May	Hr	0.95	1.10	1.16	2.14	1.76	1.71	0.95	1.10
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.05	5.06	5.05	5.06	5.06	5.06	5.06
OC Oct.	Tshs	0.49	0.24	0.81	0.68	0.98	0.86	0.49	0.24
OC Nov.	Tshs	0.49	0	0.20	0.13	0.07	0.05	0.49	0
WP LMT Oct.	Hr	1.37	1.0.	0	0	0	0	1.37	1.01
WP LMT Nov.	Hr	1.66	1.16	1.79	1.02	1.52	0.95	1.66	1.16
WP LMT May	Hr	0	0.27	0	0.35	0	0.14	0	0.08

for labor was met by working parties in May, which in turn became a constraint. Operating capital, which was a limiting factor in October and November, was still a limiting factor in October for all models and in November for Models A_2 and A_3. These MVPs of operating capital, however, were lower than the MVPs in the base plans.

The results under Alternative III, like those in the other alternatives, indicated that, with more operating capital, farmers could increase their net farm incomes and reduce the resource constraints in production. However, this would clearly be against the objective of the government, i.e., to increase the output of cotton and maize, not to increase one at the expense of the other. The results in the three alternatives indicated that seasonal labor bottlenecks were still the main constraints to expanding the area under cultivation and consequently the cotton and maize yields. The employment of owned or hired ox-drawn equipment was limited to land preparation. Farmers did not know how to use ox teams for planting, weeding, or harvesting.

There are two possible ways of alleviating seasonal labor bottlenecks. One solution is to space out farm operations between maize and cotton by having one of these crops planted late. The other is through mechanization (whether by animal draft power or tractor) of farm operations that are currently limited by labor bottlenecks. The latter option is discussed in the summary of this chapter and in the discussion of policy issues in Chapter VII. The first cropping option is examined in the discussion of Model B below.

Model B:

Mechanization and Manual Technologies: Maize, Early Cotton, and Late Cotton

If farmers were to plant one of these crops late, maize would not be the likely choice. Maize is their main food crop, and farmers would not take any risk by growing it late. Cotton, therefore, is a better choice.[1] Late-planted cotton has lower yields. In the analysis, January was taken as the planting month for late cotton. If cotton were planted in January, yields per hectare would fall by about 20 percent.

By including late-planted cotton, crop production activities increase to three. The input coefficients for late-planted cotton were similar to those for early cotton except that they were shifted downward. As an example, the family labor input coefficient for early cotton in August was shifted to September, that in September was shifted to October, and so on. The results for the analysis are presented in Tables 6.14 and 6.15.

By introducing late-planted cotton as an optional production activity, early-planted cotton was not included in the optimal solution except in Model B_2. As shown in the results for Models B_1 and B_4, the area planted in maize expanded from 1.23 hectares in the actual average to 1.34 hectares in the optimal solution, an increase of 8.94 percent. The area under late-planted cotton came to 1.75 hectares.

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[1]About 93.5 percent of the farmers interviewed indicated that if they were to choose which crop to grow late, they would choose cotton.

Table 6.14

Comparison of Bench-Mark and Optimal Organizations Under Existing Resources and the Official Price for Early Cotton and Late Cotton, and Free-Market Price for Maize for Participants

ITEM	UNIT	BENCH-MARK	OPTIMAL ORGANIZATIONS							
			MODEL B_1	% CHANGE	MODEL B_2	% CHANGE	MODEL B_3	% CHANGE	MODEL B_4	% CHANGE
Net Farm Income (NFI)	Tshs	4706.86	5129.03	+ 8.96	5304.68	+12.70	5157.37	+ 9.57	5129.03	+ 8.96
Land (Early Cotton)	Ha	1.29	0	-100	0.27	-79.07	0	-100	0	-100
Land (Maize)	Ha	1.23	1.34	+ 8.94	1.36	+10.57	1.37	+11.38	1.34	+ 8.96
Land (Late Cotton)	Ha	0	1.75	+100	1.49	+100	1.73	+100	1.75	+100
Total Land	Ha	2.52	3.09	+22.61	3.12	+23.41	3.10	+23.01	3.09	+22.61
Family Labor	Hrs	2843.70	3992.01	+40.38	3984.56	+40.12	3981.21	+40.00	3992.01	+40.38
Hired Labor	Hrs	298.00	0	-100	0	-100	0	-100	0	-100
Working Party	Hrs	807.00	802.09	- 0.61	754.69	- 6.48	780.17	- 3.32	802.00	- 0.61
Total Labor	Hrs	3948.70	4794.10	+21.40	4739.25	+20.02	4761.38	+20.58	4794.10	+21.40
Ox Team (Owned)	Ox Hrs	75.09	-	-	92.68	+23.24	-	-	-	-
Ox Team (Hired)	Ox Hrs	41.50	-	-	-	-	45.63	+ 9.95	-	-
Tractor (Hired)	Trc Hrs	5.35	-	-	-	-	-	-	0	-100
Operating Capital	Tshs	1552.15	1296.60	-16.46	1391.44	-10.35	1418.71	+ 8.59	1296.60	-16.46
NFI/Ha	Tshs	1867.80	1659.88	-11.13	1700.22	- 8.97	1663.67	-10.93	1659.88	-11.13
NFI/Hr of Unpd Labor	Tshs	1.66	1.28	-22.89	1.33	-19.87	1.29	-22.29	1.28	-22.89
NFI/Operating Capital	Tshs	3.03	3.95	+30.36	3.81	+25.74	3.63	+19.80	3.95	+30.36

Changes in the use of other resources were also significant. Whereas the employment of family labor increased by 40.38 percent, that of hired labor and working parties declined by 100 percent and 0.61 percent respectively from those in the actual situation. The use of operating capital decreased from Tshs 1552.15 to Tshs 1296.60, a decline of 16.46 percent.

After these changes, the net farm income came to Tshs 5129.03, an increase of 8.96 percent from Tshs 4706.86 in the actual average. The net farm income per hectare and the return to unpaid labor decreased by 11.13 percent and 22.89 percent respectively. Only the return to a unit of operating capital increased--it increased from Tshs 3.03 in the actual average to Tshs 3.95 in the optimal plan, an increase of 30.36 percent.

The optimal solution in Model B_2, which included the use of owned ox-drawn equipment included 0.27 hectares of early cotton, 1.49 hectares of late cotton, and 1.36 hectares of maize. These changes represented a 79.07 percent decline in the area planted in early cotton, a 100 percent and a 10.57 percent increase in the area under late-planted cotton and maize respectively. Total land cultivated increased by 23.41 percent. Whereas the employment of family labor increased by 40.12 percent, hired labor and working parties declined by 100 percent and 6.48 percent respectively. Whereas employment of owned ox-drawn equipment increased by 23.24 percent, use of operating capital fell from Tshs 1552.15 to Tshs 1391.44, a 10.35 percent decrease.

The net farm income increased from Tshs 4706.86 in the actual average to Tshs 5304.68 in the optimal solution. This represented an

increase of 12.70 percent. This increase together with the changes in the use of family labor, area cultivated, and operating capital led to a decrease of 19.87 percent and 8.97 percent in the return to unpaid labor and land respectively, and an increase of 25.74 percent in return to a unit of operating capital.

In the results for Model B_3, which included the hiring of ox-drawn equipment, the highest increase was shown in the area planted in maize; it increased from 1.23 to 1.37 hectares, an increase of 11.38 percent. Although the optimal solution did not include early-planted cotton, the area under late-planted cotton came to 1.73 hectares. Compared to the actual average employment of hired labor and working parties declined by 100 percent and 3.32 percent respectively. Meanwhile, employment of family labor, hired ox-drawn equipment, and operating capital increased by 40.00 percent, 9.95 percent, and 8.59 percent.

As a result of the above changes in the use of resources, the estimated net farm income came to Tshs 5157.35, an increase of 9.57 percent from Tshs 4706.86 in the actual average. The net average return per hectare was Tshs 1663.67 compared to Tshs 1867.80 in the actual average, a decrease of 10.93 percent. Net farm income per man hour of unpaid labor was Tshs 1.29 compared to Tshs 1.66, a 22.29 percent decline. Finally, the net return per unit of operating capital was Tshs 3.63 compared to Tshs 3.03 for the actual average situation, an increase of 19.80 percent.

Marginal-Value Products (MVPs in Tshs) of Resources Under Model B

In Table 6.15, the MVPs of resources under Model B_1 are given. Land was still in excess supply as shown by its zero MVPs. The incorporation of late-planted cotton did not bring enough land into use to make it a constraint on production. However, much more land was employed in this model than in Model A (see Tables 6.4 to 6.6).

The MVPs for labor in November to February and in May were lower in Models B_1 to B_4 than their corresponding MVPs in the base plans for Models A_1 to A_4. In March and April, however, the MVPs for labor were positive as compared with zero for the same months in Models A_1 to A_4. These changes in the MVPs for labor were quite understandable. In Model A, land cultivation, ridging, planting, first weeding, and second weeding for early-planted cotton and maize took place during the same months, which required a great deal of labor per farm operation. In Model B, however, these farm operations were spaced out by introducing late-planted cotton. Thus, the coincidence of the same operation taking place for both crops at the same time was avoided. By doing this, seasonal labor demands were reduced. The MVPs of family labor in March and April were exceptions to the above argument. The high MVP of family labor in March compared zero in Models A_1 to A_4 was caused by a high demand for labor that resulted from an expanded area under late cotton. It should be noted that for late-planted cotton, March would be the period for second weeding, an operation that requires more labor than either the first, third, or fourth weedings. As for April, there would be a coincidence of demand for family labor between the third weeding of cotton and harvesting of maize. Such a high demand for labor

Table 6.15

Marginal-Value Products (MVPs in Tshs) of Resources for Models B_1 to B_4 Under Early Cotton, Late Cotton and Maize for Participants

RESOURCE	UNIT	Model B_1		Model B_2		Model B_3		Model B_4	
		Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan
FL Oct.	Hr	2.99	0	0	0	0	0	2.99	0
FL Nov.	Hr	2.75	1.36	2.87	1.50	2.59	1.90	2.75	1.36
FL Dec.	Hr	1.08	0.14	1.60	0.97	1.40	1.38	1.08	0.14
FL Jan.	Hr	0.93	0.60	1.28	0.22	1.19	0.29	0.93	0.60
FL Feb.	Hr	1.12	0.92	2.03	1.04	2.21	0.82	1.12	0.92
FL Mar.	Hr	0	3.88	0	4.15	0	3.94	0	3.88
FL Apr.	Hr	0	1.07	0	1.33	0	1.01	0	1.07
FL May	Hr	0.95	0.52	1.16	0.76	1.76	0.66	0.95	0.52
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
OC Oct.	Tshs	0.49	0	0.81	0	0.98	0	0.49	0
OC Nov.	Tshs	0.49	0.28	0.20	0.19	0.07	0.42	0.49	0.28
OC Dec.	Tshs	0	0.12	0	0.06	0	0.25	0	0.12
WP LMT Oct.	Hr	1.37	0	0	0	0	0	1.37	0
WP LMT Nov.	Hr	1.66	0.41	1.79	0	1.52	0	1.66	0.41

would also be caused by an expanded cultivated area for crops in Model B. Although the MVPs for November working parties declined from 1.66 Tshs in Models A_1 and A_4 to Tshs 0.41 in Models B_1 and B_4, the MVPs of working parties in October for Models B_1 and B_4 and November for Models B_2 and B_3 declined from positive MVPs to zero.

Unlike Models A_1 to A_4, in which the MVPs of operating capital were positive in October and November, the MVPs of operating capital were positive for November and December in Models B_1 to B_4. The incorporation of late-planted cotton, therefore, did not totally remove the operating-capital constraints; it only shifted the constraints.

Although the results in Model B were not better in terms of net farm income, than those in Model A, they indicated a substantial potential for minimizing seasonal labor bottlenecks and increasing farm income if biological technologies that might produce high-yielding late-planted cotton seeds were introduced. The empirical findings indicated that land is not a limiting factor. Such information is of value to policy makers in determining the extent to which emphasis should be put in land-saving techniques or labor-saving techniques.

Optimal Organizations with Existing Resources and Prices for Nonparticipating Farmers

In this section, a discussion is presented of the nonparticipating farmers. This discussion is parallel to that given for participating farmers. First, Model C for maize and early-planted cotton is discussed. Then Model D for late-planted cotton is discussed. Alternative ways of applying the models are also presented as they were for Models A and B.

Model C:

Mechanization and Manual Technologies: Maize and Early Cotton for Nonparticipants

In Table 6.16, a comparison between the bench-mark and optimal organizations of the representative farm for the nonparticipants is given. Four submodels are represented in the table: Model C_1, representing farmers who employ only labor for farm operations; Model C_2, representing farmers who employ labor and owned ox-drawn equipment; Model C_3, representing farmers who, in addition to labor, employ hired ox-drawn equipment; Model C_4, representing farmers who employ labor and hired tractor power.

In the analysis, it was shown that the results for Models C_1, C_3, and C_4 were the same. Since there was no use of hired ox-drawn equipment in Model C_3 or of tractor power in Model C_4, all farm operations were done by manual technology. As a result, the areas planted in the crops were to be determined by the seasonal availability of labor and other resources.

Compared to the bench-mark, the areas planted in maize and cotton changed substantially in all four models. In Models C_1, C_3, and C_4, the area planted in maize decreased from 1.38 hectares under the bench-mark to 0.43 hectares in the optimal organizations. This represented a 68.84 percent decline. On the other hand, the area planted in cotton increased from 1.25 to 2.02 hectares, an increase of 61.60 percent. The total area cultivated declined by 6.46 percent.

The decline in land cultivated led to a decline in the employment of other resources. If no labor was hired, family labor and working

Table 6.16

Comparison of Bench-Mark and Optimal Organizations Under Existing Resources and the Official Prices for Maize and Early Cotton for Nonparticipants

ITEM	UNIT	BENCH-MARK	OPTIMAL ORGANIZATIONS							
			MODEL C_1	% CHANGE	MODEL C_2	% CHANGE	MODEL C_3	% CHANGE	MODEL C_4	% CHANGE
Net Farm Income (NFI)	Tshs	2983.27	3657.91	+22.61	3821.54	+28.09	3657.91	+22.61	3657.91	+22.61
Land (Early Cotton)	Ha	1.25	2.02	+61.60	2.14	+71.20	2.02	+61.60	2.02	+61.60
Land (Maize)	Ha	1.38	0.43	-68.84	0.43	-68.84	0.43	-68.84	0.43	-68.84
Land (Late Cotton)	Ha	-	-	-	-	-	-	-	-	-
Total Land	Ha	2.63	2.46	- 6.46	2.57	- 2.83	2.46	- 6.46	2.46	- 6.46
Family Labor	Hrs	4192.16	4069.07	- 2.94	3913.55	- 6.65	4069.07	- 2.94	4069.07	- 2.94
Hired Labor	Hrs	68.00	0	-100	0	-100	0	-100	0	-100
Working Party	Hrs	114.70	83.15	-27.51	76.48	-33.32	83.15	-27.51	83.15	-27.51
Total Labor	Hrs	4374.86	4152.22	- 5.08	3990.03	- 8.79	4152.22	- 5.08	4152.22	- 5.08
Ox Team (Owned)	Ox Hrs	78.90	-	-	76.58	- 2.94	-	-	-	-
Ox Team (Hired)	Ox Hrs	26.75	-	-	-	-	0	-100	-	-
Tractor (Hired)	Trc Hrs	4.80	-	-	-	-	-	-	0	-100
Operating Capital	Tshs	856.35	702.85	-17.92	730.24	-14.72	702.85	-17.92	702.85	-17.92
NFI/Ha	Tshs	1134.32	1486.95	+31.08	1486.98	+31.09	1486.95	+31.08	1486.95	+31.08
NFI/Hr of Unpd Labor	Tshs	0.71	0.89	+26.61	0.97	+37.53	0.89	+26.61	0.89	+26.61
NFI/Operating Capital	Tshs	3.48	5.20	+49.55	5.23	+ 0.58	5.20	+49.55	5.20	+49.55

parties declined by 2.94 percent and 27.51 percent respectively. Total labor employed declined by 5.08 percent, which was lower than the percentage decline in total land cultivated. This was simply because more labor was required to farm the expanded cotton area because cotton requires more labor per hectare than does maize. Operating capital declined from Tshs 856 in the bench-mark to Tshs 702.85, a 17.92 percent fall.

The optimum net farm income came to Tshs 3657.91 compared to Tshs 2983.27, an increase of 22.61 percent. The changes in net farm income and in the employment of resources led to increases in net farm income per hectare, per unpaid labor, and per unit of operating capital; these increased by 31.08 percent, 26.61 percent, and 49.55 percent respectively.

The results for Model C_2 were noticeably different. Whereas the change in the area planted in maize was the same as those in Models C_1, C_3, and C_4, the area planted in cotton was the largest. It increased from 1.25 hectares in the bench-mark to 2.14 hectares in the optimal solution. The decline in total cultivated land was only 2.83 percent. As in the other models, no labor was hired in the optimal solution. Employment of family labor, labor from working parties, and owned ox-drawn equipment declined by 6.65 percent, 33.32 percent, and 2.94 percent respectively. In addition, use of operating capital declined from Tshs 856.35 in the bench-mark to Tshs 730.24, a fall of 14.72 percent.

The estimated net farm income increased from Tshs 2983.27 to Tshs 3821.54, a 28.09 percent increase. Consequently, the return to land, to unpaid labor, and to a unit of operating capital increased by 31.09 percent, 37.53 percent, and 0.58 percent respectively.

In Table 6.17, bench-mark and optimal organizations are compared with the official price for maize replaced by the free market price of Tshs 2.50 per kilogram. Again, the results for Models C_1, C_3, and C_4 were the same. The area planted in maize increased by 9.42 percent, whereas that planted in cotton declined by 10.40 percent. Total land cultivated did not change. Although the decline of the cotton area by 0.13 hectares was offset by an increase of the same size for maize, employment of labor and operating capital declined. Family labor, labor from working parties, and operating capital declined by 9.87 percent, 76.02 percent and 33.46 percent respectively.

The change in net farm income was not substantial; it increased from Tshs 4027.18 in the bench-mark to Tshs 4260.83, an increase of 5.80 percent. As there was no change in total land cultivated, the return to land also increased by 5.80 percent. However, substantial declines in the employment of family labor and operating capital led to substantial increases in return to unpaid labor and to a unit of operating capital by 32.29 percent and 92.96 percent respectively.

In the optimal solution for Model C_2, a further decline in the cotton area was observed. From 1.25 hectares in the bench-mark, the cotton area declined to 1.09 hectares. The area lost by cotton was gained by maize, for which the area increased from 1.38 to 1.54 hectares. Consequently, there was no change in total land cultivated. Because of the use of owned ox-drawn equipment, employment of labor was much less in this model. Use of family labor declined by 16.35 percent, whereas that of working parties declined by 88.95 percent.

Table 6.17

Comparison of Bench-Mark and Optimal Organizations Under Existing Resources and the Officel Price for Early Cotton and Free-Market Price for Maize for Nonparticipants

ITEM	UNIT	BENCH-MARK	OPTIMAL ORGANIZATIONS							
			MODEL C_1	% CHANGE	MODEL C_2	% CHANGE	MODEL C_3	% CHANGE	MODEL C_4	% CHANGE
Net Farm Income (NFI)	Tshs	4027.18	4260.83	+ 5.80	4211.49	+ 4.58	4260.83	+ 5.80	4260.83	+ 5.80
Land (Early Cotton)	Ha	1.25	1.12	-10.40	1.09	-12.80	1.12	-10.40	1.12	-10.40
Land (Maize)	Ha	1.38	1.51	+ 9.42	1.54	+11.59	1.51	+ 9.42	1.51	+ 9.42
Land (Late Cotton)	Ha	-	-	-	-	-	-	-	-	-
Total Land	Ha	2.63	2.63	0	2.63	0	2.63	0	2.63	0
Family Labor	Hrs	4192.16	3778.23	- 9.87	3506.40	-16.35	3778.23	- 9.87	3778.23	- 9.87
Hired Labor	Hrs	68.00	0	-100	0	-100	0	-100	0	-100
Working Party	Hrs	114.70	27.51	-76.02	12.67	-88.95	27.51	-76.02	27.51	-76.02
Total Labor	Hrs	4374.86	3805.74	-13.00	3519.07	-19.56	3805.74	-13.00	3805.74	-13.00
Ox Team (Owned)	Ox Hrs	78.90	-	-	78.90	0	-	-	-	-
Ox Team (Hired)	Ox Hrs	26.75	-	-	-	-	0	-100	-	-
Tractor (Hired)	Trc Hrs	4.80	-	-	-	-	-	-	0	-100
Operating Capital	Tshs	856.35	569.80	-33.46	595.52	-30.45	569.80	-33.46	569.80	-33.46
NFI/Ha	Tshs	1531.24	1620.09	+ 5.80	1601.32	+ 4.58	1620.09	+ 5.80	1620.09	+ 5.80
NFI/Hr of Unpd Labor	Tshs	0.96	1.27	+32.29	1.20	+25.11	1.27	+32.29	1.27	+32.29
NFI/Operating Capital	Tshs	4.70	9.07	+92.96	7.07	+50.46	9.07	+92.96	9.07	+92.96

The decline of 30.45 percent in the use of operating capital, however, was a little lower than that in the other models. If a farmer employed owned ox-drawn equipment in Model C_2, he incurred operating costs (see Chapter V). The decline in operating capital would have been much lower in this model if the area planted in cotton declined by a smaller percentage. This was because more inputs were used in cotton production than in maize production.

From Tshs 4027.18 in the bench-mark, the estimated net farm income increased to Tshs 4211.49, an increase of 4.58 percent. As a result, net farm income increased by 4.58 percent, return to unpaid labor increased by 25.11 percent, and return to a unit of operating capital increased by 50.46 percent.

Marginal-Value Products of Resources Under Model C

The MVPs of resources used in the production of maize and cotton in Models C_1 to C_4 are shown in Table 6.18. The MVPs of resources in Models C_1, C_3, and C_4 were the same. At the official maize price of Tshs 1.00, land was in excess supply in Models C_1 to C_4, as shown by its zero MVP. At a free-market price for maize, the MVP of land became Tshs 465.22 for Models C_1, C_3, and C_4, and Tshs 514.67 for Model C_2; both reflected the scarcity of land. Thus, if one hectare were brought into cultivation under Models C_1, C_3, and C_4, income would increase by Tshs 465.22, whereas under Model C_2, the increase in income would be Tshs 514.67. Similarly, a reduction of land under cultivation by one hectare would decrease income by the amounts of MVPs indicated above. The MFC of land was assumed to be zero since no land was

Table 6.18

Marginal-Value Products (MVPs in Tshs) of Resources for Models C_1 to C_4 for Nonparticipants

RESOURCE	UNIT	Model C_1		Model C_2		Model C_3		Model C_4	
		PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50	PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50	PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50	PCTN=3.20 PMZE=1.00	PCTN=3.20 PMZE=2.50
Land	Ha	0	465.22	0	514.67	0	465.22	0	465.22
FL Oct.	Hr	0.27	1.64	0	0	0.27	1.64	0.27	1.64
FL Nov.	Hr	0.19	1.81	0.33	0.98	0.19	1.81	0.19	1.21
FL Jan.	Hr	0	0	0	1.06	0	0	0	0
FL Feb.	Hr	0	1.04	0	1.55	0	1.04	0	1.04
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06

bought or rented. The MVPs of family labor in August, September, October (for Model C_2), December, and March to June, the MVPs of owned ox-drawn equipment in October to December, operating capital, hired labor, and labor from working parties were all zero irrespective of which of the two maize prices was used. Family labor constraints were observed in October for Models C_1, C_3, and C_4; in November for all models; in January for Model C_2 (when the maize price was Tshs 2.50), and in February for all models (when the price for maize was Tshs 2.50). These were the peak labor periods for these farmers. A great deal of labor for cultivating and ridging the land was required in October and November; in January and particularly in February, much labor was required for weeding of cotton and maize to fight weeds that grow rapidly due to heavy rains. The MVPs of TSP, SA, Thoidan, and DDT were equal to their prices. In the absence of data on production responses to these inputs, it was not known if the optimum use of these resources had been achieved.

Optimal Organizations of the Nonparticipants' Representative Farms with Variable Product, Fertilizer, and Insecticide Prices, and Operating-Capital Levels for Models C_1 to C_4

The impact of input and output price changes on net farm income, cropping patterns, and resource use under Models C_1 and C_4 is discussed in this section. No attempt was made to explore the impact of changing operating capital levels since the resource was not a constraint in the base plan.

Alternative I:

Changes in the Relative Prices of Early Cotton and Maize

The relative prices of cotton and maize were increased by the same proportion as those discussed in section one of this chapter. These price changes are discussed under Alternatives Ia, Ib, and Ic. Because of relative price changes under Alternative Ia (Table 6.19), the area planted in maize decreased by 63.57 percent; the area planted in cotton increased by 85.71 percent under Models C_1, C_3 and C_4. There was no change in total land cultivated. Compared to the base plan, employment of labor increased from 3805.74 to 3978.08 man hours. All of this increase, however, came from family labor; its employment increased by 4.78 percent whereas that of working parties declined by 31.04 percent. Use of operating captial increased from Tshs 569.80 in the base plan to Tshs 624.77 in the optimal organization, an increase of 9.64 percent. Most of this increase resulted from the increase in cotton hectarage, for much more purchased inputs per hectare were required by cotton than by maize.

The estimated net farm income came to Tshs 3908.62 compared to Tshs 4260.83 in the base plan. This represented a decrease of 8.26 percent. As a result, net farm income per hectare fell by the same percentage, return to unpaid labor and to a unit of operating capital declined by 22.83 percent and 31.09 percent respectively.

Under Model C_2, the results followed more or less the same pattern as those discussed above. Whereas the cotton area increased by 88.07 percent, the are planted in maize declined by 62.34 from that for the

Table 6.19

Efficiency Measures for the Base Plans and Changes in Relative Product Prices for Maize and Early Cotton for Nonparticipants: Alternative I_a

ITEM	UNIT	Base Plan for Model C_1	New Plan for C_1	% Change	Base Plan for Model C_2	New Plan for C_2	% Change	Base Plan for Model C_3	New Plan for C_3	% Change	Base Plan for Model C_4	New Plan for C_4	% Change
Net Farm Income (NFI)	Tshs	4260.83	3908.62	- 8.26	4211.49	3896.58	- 7.47	4260.83	3908.62	- 8.26	4260.83	3908.62	- 8.26
Land (Early Cotton)	Ha	1.12	2.08	+85.71	1.09	2.05	+88.07	1.12	2.08	+85.71	1.12	2.08	+85.71
Land (Maize)	Ha	1.51	0.55	-63.57	1.54	0.58	-62.34	1.51	0.55	-63.57	1.51	0.55	-63.57
Total Land	Ha	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0
Family Labor	Hrs	3778.23	3959.11	+ 4.78	3506.40	3660.05	+ 4.38	3778.23	3959.11	- 4.78	3778.23	3959.11	- 4.78
Hired Labor	Hrs	0	0	0	0	0	0	0	0	0	0	0	0
Working Party	Hrs	27.51	18.97	-31.04	12.67	0	-53.94	27.51	18.97	-31.04	27.51	18.97	-31.04
Total Labor	Hrs	3805.74	3978.08	+ 4.53	3519.07	3660.05	+ 4.00	3805.74	3978.08	+ 4.53	3805.74	3978.08	+ 4.53
Ox Team (Owned)	Ox Hrs	-	-	-	78.90	78.90	0	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	0	0	0	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	569.80	624.77	+ 9.64	595.52	653.31	+ 9.70	569.80	624.77	+ 9.24	569.80	624.77	+ 9.24
NFI/Ha	Tshs	1620.09	1486.16	- 8.27	1601.32	1481.59	- 7.47	1620.09	1486.16	- 8.27	1620.09	1486.16	- 8.27
NFI/Hr of Unpaid Labor	Tshs	1.27	0.98	-22.83	1.20	1.06	-11.67	1.27	0.98	-22.83	1.27	0.98	-22.83
NFI/Operating Capital	Tshs	9.07	6.25	-31.09	7.07	5.96	-15.70	9.07	6.25	-31.09	9.07	6.25	-31.09

base plan. Again, the total area cultivated remained unchanged. Although there was no employment of hired labor and although labor from working parties declined by 53.94 percent, use of labor increased by 4.00 percent due to a 4.38 percent increase in the employment of family labor. The change in the employment of owned ox-drawn equipment was zero; operating capital increased by 9.70 percent.

The estimated net farm income decreased from Tshs 4211.49 in the base plan to Tshs 3896.58 in the optimal organization, a fall of 7.47 percent. With no change in total area cultivated, return to land changed by the same percentage. The average return to unpaid labor declined by 11.67 percent, whereas that to a unit of operating capital decreased by 15.70 percent.

As in Alternative Ia, there were substantial changes under Alternative Ib (as shown in Table 6.20). The results in Models C_1, C_3, and C_4 were again the same. The area planted in cotton increased by 91.07 percent, that planted in maize declined by 67.55 percent, and the total cultivated area remained the same. Despite the decline in the area planted in maize, the increase in the cotton area led to increases in the employment of labor and operating capital. The optimal use of family labor, labor from working parties, and operating capital increased by 6.29 percent, 140.60 percent, and 25.71 percent respectively from those under the base plan.

The optimum net farm income came to Tshs 4718.48 compared to Tshs 4260.83, an increase of 10.74 percent. Consequently, the return to land increased by 10.74 percent since there was no change in total area cultivated. In addition, the average return to unpaid labor

Table 6.20

Efficiency Measures for the Base Plans and Changes in Relative Product Prices for Maize and Early Cotton for Nonparticipants: Alternative I_b

ITEM	UNIT	Base Plan for Model C_1	New Plan for C_1	% Change	Base Plan for Model C_2	New Plan for C_2	% Change	Base Plan for Model C_3	New Plan for C_3	% Change	Base Plan for Model C_4	New Plan for C_4	% Change
Net Farm Income (NFI)	Tshs	4260.83	4718.48	+10.74	4211.49	4632.79	+10.00	4260.83	4718.48	+10.74	4260.83	4718.48	+10.74
Land (Early Cotton)	Ha	1.12	2.14	+91.07	1.09	2.17	+99.08	1.12	2.14	+91.07	1.12	2.14	+91.07
Land (Maize)	Ha	1.51	0.49	-67.55	1.54	0.46	-70.13	1.51	0.49	-67.55	1.51	0.49	-65.55
Total Land	Ha	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0
Family Labor	Hrs	3778.23	4015.80	+ 6.29	3506.40	3667.86	+ 4.60	3778.23	4015.80	+ 6.29	3778.23	4015.80	+ 6.29
Hired Labor	Hrs	0	0	0	0	0	0	0	0	0	0	0	0
Working Party	Hrs	27.51	66.19	+140.60	12.67	45.01	+255.24	27.51	66.19	+140.60	27.51	66.19	+140.60
Total Labor	Hrs	3805.74	4081.99	+ 7.26	3519.07	3712.87	+ 5.51	3805.74	4081.99	+ 7.26	3805.74	4081.99	+ 7.26
Ox Team (Owned)	Ox Hrs	-	-	-	78.90	78.90	0	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	0	0	0	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	569.80	716.28	+25.71	595.52	768.27	+29.00	569.80	716.28	+25.71	569.80	719.28	+25.71
NFI/Ha	Tshs	1620.09	1794.09	+10.74	1601.32	1761.51	+10.00	1620.09	1794.09	+10.74	1620.09	1794.09	+10.74
NFI/Hr of Unpaid Labor	Tshs	1.27	1.17	- 8.26	1.20	1.26	+ 5.00	1.27	1.17	- 8.26	1.27	1.17	- 8.26
NFI/Operating Capital	Tshs	9.07	6.58	-27.45	7.07	6.03	+14.71	9.07	9.07	-27.45	9.07	6.58	-27.45

declined by 8.26 percent and that to a unit of operating capital fell by 27.45 percent.

In Model C_2, the area planted in maize declined by 70.13 percent; this decline was offset by an increase of 99.08 percent in the cotton hectarage. Although there was no change in total cultivated land or in the employment of owned ox-drawn equipment, employment of family labor increased by 4.60 percent, of labor from working parties by 255.24 percent (27.51 to 45.01 man hours), and of operating capital by 29.00 percent. The estimated net farm income came to Tshs 4632.79, an increase of 10.00 percent from Tshs 4211.49 in the base plan. The net farm income per hectare, per man hour of family labor, and per unit of operating capital increased by 10.00 percent, 5.00 percent, and 14.71 percent respectively.

In Table 6.21 the results for Alternative Ic are given. As for the first two alternatives; the results for Models C_1, C_3 and C_4 were the same. Both cotton and maize became fairly competitive. The area planted in cotton increased from 1.12 hectares in the base plan to 1.24 hectares in the optimal organization. This represented a 10.71 percent increase. The area planted in maize, on the other hand, declined by 7.94 percent. These changes left the total cultivated area unchanged. Since sotton required more inputs per hectare than maize, employment of labor and operating capital increased. The use of family labor increased by 1.28 percent, labor from working parties by 42.20 percent, and operating capital by 7.34 percent.

The optimum net farm income came to Tshs 5514.13 compared to 4260.83 in the base plan; this was an increase of 29.42 percent. The changes in

Table 6.21

Efficiency Measures for the Base Plans and Changes in Relative Product Prices for Maize and Early Cotton for Nonparticipants: Alternative I_c

ITEM	UNIT	Base Plan for Model C_1	New Plan for C_1	% Change	Base Plan for Model C_2	New Plan for C_2	% Change	Base Plan for Model C_3	New Plan for C_3	% Change	Base Plan for Model C_4	New Plan for C_4	% Change
Net Farm Income (NFI)	Tshs	4260.83	5514.31	+29.42	4211.49	5620.52	+33.45	4260.83	5514.31	+29.42	4260.83	5514.31	+29.42
Land (Early Cotton)	Ha	1.12	1.24	+10.71	1.09	1.28	+17.43	1.12	1.24	+10.71	1.12	1.24	+10.71
Land (Maize)	Ha	1.51	1.39	- 7.94	1.54	1.35	-12.34	1.51	1.39	- 7.94	1.51	1.39	- 7.94
Total Land	Ha	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0
Family Labor	Hrs	3778.23	3826.55	+ 1.28	3506.40	3592.88	+ 2.47	3778.23	3826.55	+ 1.28	3778.23	3865.67	+ 1.28
Hired Labor	Hrs	0	0	0	0	0	0	0	0	0	0	0	0
Working Party	Hrs	27.51	39.12	+42.20	12.67	15.73	+24.15	27.51	39.12	+42.20	27.51	39.12	+42.20
Total Labor	Hrs	3805.74	3865.67	+ 1.57	3519.07	3608.61	+ 2.54	3805.74	3865.67	+ 1.57	3805.74	3865.67	+ 1.57
Ox Team (Owned)	Ox Hrs	-	-	-	78.90	78.90	0	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	0	0	0	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	569.80	611.63	+ 7.34	595.52	605.37	+ 1.65	569.80	611.63	+ 7.34	569.80	611.63	+ 7.34
NFI/Ha	Tshs	1620.09	2096.69	+29.42	1601.32	2137.08	+33.45	1620.09	2096.69	+29.42	1620.09	2096.69	+29.42
NFI/Hr of Unpaid Labor	Tshs	1.27	1.44	+13.47	1.20	1.56	+30.00	1.27	1.44	+13.47	1.27	1.44	+13.47
NFI/Operating Capital	Tshs	9.07	9.02	+ 0.55	7.07	9.28	+31.27	9.07	9.02	+ 0.55	9.07	9.02	+ 0.57

net farm income and employment of farm resources led to increases of 29.42 percent, 13.47 percent, and 0.55 percent in net farm income per hectare, per man hour of family labor, and per unit of operating capital respectively.

Contrasted to the results with Alternatives Ia and Ib, the best results for Alternative Ic were achieved under Model C_2. Although the area planted in maize declined by 12.34 percent, that planted in cotton increased by 17.43 percent, leading to no change in the total cultivated land. Employment of family labor increased by 2.47 percent, working parties by 24.15 percent, and operating capital by 1.65 percent.

Whereas the net farm income in the base plan was Tshs 4211.49, that in the optimal organization came to Tshs 5620.52. This income was higher than those in Models C_1, C_3, and C_4. The resulting changes in net farm income per hectare, per man hour of family labor, and per unit of operating capital were 33.45 percent, 30 percent, and 31.27 percent respectively.

These results provided more or less the same conclusions as those drawn in the first section of this chapter. However, there is one major difference that needs some attention. In the analyses presented so far, there was no situation in which the employment of hired ox-drawn equipment (and tractor power) was profitable. Unlike the participating farmers, nonparticipating farmers owned less average land and did not weed their farms as many times; thus demand for labor was reduced. Consequently, labor was relatively abundant for land preparation (cultivating and ridging) as well as for other farm operations.

Marginal-Value Products of Resources Under Alternative I

The MVPs of resources under Alternative Ia are shown in Table 6.22. Compared to the base plans, the MVPs of land fell in each model. Whereas in Models C_1, C_3, and C_4, the MVPs of land fell from Tshs 465.22 to Tshs 371.60, that in Model C_2 fell from Tshs 514.67 to Tshs 401.48. Other notable changes were in the MVPs of family labor in November, January (for Model C_2), and February for all models. In November, the MVPs of family labor for Models C_1, C_3, and C_4, increased from Tshs 1.81 in the base plan to Tshs 1.96 in the new plan. For the same month, the MVP of family labor in Model C_2 increased from Tshs 0.98 to Tshs 1.15. For Model C_2, the MVP of family labor in January increased from Tshs 1.06 to Tshs 1.32. Finally, the MVPs of family labor increased from Tshs 1.04 to Tshs 1.23 in Models C_1, C_3, and C_4, and from 1.55 to Tshs 1.89 in Model C_2. The increase in cotton hectarage was the cause of these changes. In November, ridging of land for both cotton and maize took place. Cotton ridges were bigger (in terms of width and height) and required more labor to make than maize ridges. This increased demand for labor and pushed up the MVP of family labor. In January and February, first and second weeding took place. An hectare of cotton required more labor than an hectare of maize, because during the first cotton weeding, farmers also applied greater quantities of sulphate of ammonia in addition to thinning and spraying. During the second weeding, spraying added to the demand for labor. Although SA application, thinning, and spraying were also done for maize, they were not done to such a great extent.

Table 6.22

Marginal-Value Products (MVPs in Tshs) of Resources for Models C_1 to C_4 for Nonparticipants: Alternative Ia

RESOURCE	UNIT	Model C_1		Model C_2		Model C_3		Model C_4	
		Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan
Land	Ha	465.22	371.60	514.67	401.48	465.22	371.60	465.22	371.60
FL Oct.	Hr	1.64	1.64	0	0	1.64	1.64	1.64	1.64
FL Nov.	Hr	1.81	1.96	0.98	1.15	1.81	1.96	1.81	1.96
FL Jan.	Hr	0	0	1.06	1.32	0	0	0	0
FL Feb.	Hr	1.04	1.23	1.55	1.89	1.04	1.23	1.04	1.23
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06

In Alternative Ib (see Table 6.23) more or less the same results as those for Ia were obtained. The MVPs of land declined in each model, from Tshs 465.22 in the base plans to Tshs 316.97 in the new plans for Models C_1, C_3, and C_4, and from Tshs 514.67 to Tshs 382.34 for Model C_2. The MVPs of family labor in November, January (for Model C_2), February, and June (for Model C_2) were higher than their corresponding MVPs in the base plans. The resons for these changes were the same as for those in Alternative Ia.

The MVPs of resources under Alternative Ic are given in Table 6.24. The results followed the same pattern as those for Alternative Ia and Ib. The only exception was the increase in the MVPs of land in each model. In Models C_1, C_3, and C_4, the MVPs of land increased from 465.22 in the base plans to Tshs 483.14 in the new plans. The MVP of land in Model C_2 came to Tshs 559.36 compared to Tshs 514.67 in the base plan. These changes implied that land became more restricting. The November MVPs of family labor increased from Tshs 1.81 to Tshs 1.92 for Models C_1, C_3, and C_4, and from Tshs 0.98 to Tshs 1.06 for Model C_2. And, although the MVPs of family labor in January and February increased from Tshs 1.06 to Tshs 1.39 and from Tshs 1.55 to Tshs 1.74 respectively for Model C_2, the increase for Models C_1, C_3, and C_4 went from Tshs 1.04 to Tshs 1.22. Again, the reasons for these changes were the same as those discussed for Alternative Ia.

Alternative II: Increases in the Prices of Fertilizers and Insecticides

In Table 6.25, the changes are given for cropped areas, net farm income, and resource use that resulted from substituting subsidized with

Table 6.23

Marginal-Value Products (MVPs in Tshs) for Models C_1 to C_4 for Nonparticipants: Alternative Ib

RESOURCE	UNIT	Model C_1		Model C_2		Model C_3		Model C_4	
		Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan
Land	Ha	465.22	316.97	514.67	382.34	465.22	316.97	465.22	316.97
FL Oct.	Hr	1.64	1.64	0	0	1.64	1.64	1.64	1.64
FL Nov.	Hr	1.81	2.10	0.98	1.26	1.81	2.10	1.81	2.10
FL Jan.	Hr	0	0	1.06	1.53	0	0	0	0
FL Feb.	Hr	1.04	1.47	1.55	2.09	1.04	1.47	1.04	1.47
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06

Table 6.24

Marginal-Value Products (MVPs in Tshs) for Models C_1 to C_4 for Nonparticipants: Alternative Ic

RESOURCE	UNIT	Model C_1		Model C_2		Model C_3		Model C_4	
		Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan
Land	Ha	465.22	483.14	514.67	559.36	465.22	483.14	465.22	483.14
FL Oct.	Hr	1.64	1.64	0	0	1.64	1.64	1.64	1.64
FL Nov.	Hr	1.81	1.81	0.98	1.06	1.81	1.92	1.81	1.92
FL Jan.	Hr	0	0	1.06	1.39	0	0	0	0
FL Feb.	Hr	1.04	1.22	1.55	1.74	1.04	1.22	1.04	1.22
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06

Table 6.25

Efficiency Measures for the Base Plans and Changes in Fertilizer and Insecticide Prices for Early Cotton and Maize for Nonparticipants

ITEM	UNIT	Base Plan for Model C_1	New Plan for C_1	% Change	Base Plan for Model C_2	New Plan for C_2	% Change	Base Plan for Model C_3	New Plan for C_3	% Change	Base Plan for Model C_4	New Plan for C_4	% Change
Net Farm Income (NFI)	Tshs	4260.83	4221.65	- 0.92	4211.49	4183.47	- 0.67	4260.83	4221.65	- 0.92	4260.83	4221.65	- 0.92
Land (Early Cotton)	Ha	1.12	1.07	- 4.46	1.09	1.06	- 2.75	1.12	1.07	- 4.46	1.12	1.07	- 4.46
Land (Maize)	Ha	1.51	1.56	+ 3.21	1.54	1.57	+ 1.95	1.51	1.56	+ 3.21	1.51	1.56	+ 3.21
Total Land	Ha	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0	2.63	2.63	0
Family Labor	Hrs	3778.23	3712.44	- 1.74	3506.40	3491.05	- 0.44	3778.23	3712.44	- 1.74	3778.23	3712.44	- 1.74
Hired Labor	Hrs	0	0	0	0	0	0	0	0	0	0	0	0
Working Party	Hrs	27.51	16.59	-39.69	12.67	10.12	-20.13	27.51	16.59	-39.69	27.51	16.59	-39.69
Total Labor	Hrs	3805.74	3729.03	- 2.02	3519.07	3501.17	- 0.51	3805.74	3729.03	- 2.02	3805.74	3729.03	- 2.02
Ox Team (Owned)	Ox Hrs	-	-	-	78.90	78.90	0	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	0	0	0	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	569.80	588.25	+ 3.24	595.52	627.50	+ 6.54	569.80	588.25	+ 3.24	569.80	588.25	+ 3.24
NFI/Ha	Tshs	1620.09	1605.19	- 0.92	1601.32	1590.68	- 0.67	1620.09	1605.19	- 0.92	1620.09	1605.19	- 0.92
NFI/Hr of Unpaid Labor	Tshs	1.27	1.14	-10.24	1.20	1.19	- 0.83	1.27	1.14	-10.24	1.27	1.14	-10.24
NFI/Operating Capital	Tshs	9.07	7.18	-20.24	7.07	6.66	- 5.79	9.07	7.18	-20.84	9.07	7.18	-20.84

unsubsidized fertilizers and insecticides. The results for Models C_1, C_3, and C_4 showed that, although cotton area declined from 1.12 hectares in the base plans to 1.07 hectares in the new plans, the area planted in maize increased from 1.51 to 1.56 hectares. The total cropped area remained unchanged. Operating capital increased by 3.24 percent; the use of other resources declined. The employment of family labor and labor from working parties declined by 1.74 percent and 39.69 percent respectively; as a result, the use of labor declined by 2.02 percent.

The estimated net farm income came to Tshs 4221.65 compared to Tshs 4260.83 in the base plan, a decrease of 0.92 percent. In turn, the return to land, to unpaid labor, and to a unit of operating capital declined by 0.92 percent, 10.24 percent, and 20.84 percent respectively.

In Model C_2, the area planted in cotton declined by 2.75 percent, whereas that planted in maize increased by 1.95 percent. The employment of family labor and labor from working parties declined by 0.44 percent and 20.13 percent respectively leading to a decline of 0.51 percent in the use of labor. The use of operating capital increased by 6.54 percent from that in the base plan.

The optimum net farm income decreased from Tshs 4211.49 in the base plan to Tshs 4183.47 in the new plan, a decline of 0.67 percent. Consequently the net farm income per hectare, for unpaid labor, and per unit of operating capital declined by 0.67 percent, 0.83 percent, and 5.79 percent respectively.

Marginal-Value Products of Resources Under Alternative II

The MVPs of resources under Alternative II are presented in Table 6.26. The MVP of land declined in each model, from Tshs 465.22 in the base plans to Tshs 297.53 in the new plans for Models C_1, C_3, and C_4. For Model C_2, the MVPs declined from Tshs 514.67 in the base plan to Tshs 318.32 in the new plan.

Unlike Alternative I, in which the MVPs of family labor in November, January (for Model C_2), and February were higher than their corresponding MVPs in the base plans, in Alternative II they were lower. The reason lay in the decline in the cotton area, which released much more labor than the increase in the area planted in maize could absorb. The increase in the prices of fertilizers and insecticides produced a constraint in the December operating capital. Although this was not the time for spraying Thiodan, many farmers bought it in December because distribution is very poor when the rains become heavy in January and February.

In summary, the increase in TSP, SA, Thiodan, and DDT made cotton less competitive by reducing its area. The impact on net farm income was, therefore, negative since in each model the farmers' incomes were lower than they were under the base plans. In addition, the input-price increases constrained the December operating capital so that farmers could not expand their production even if land and labor were not constraining factors.

Table 6.26

Marginal-Value Products (MVPs in Tshs) for Models C_1 to C_4 for Nonparticipants: Alternative II

RESOURCE	UNIT	Model C_1		Model C_2		Model C_3		Model C_4	
		Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan
Land	Ha	465.22	297.53	514.67	318.32	465.22	297.53	465.22	297.53
FL Oct.	Hr	1.64	1.64	0	0	1.64	1.64	1.64	1.64
FL Nov.	Hr	1.81	1.68	0.98	0.89	1.81	1.68	1.81	1.68
FL Jan.	Hr	0	0	1.06	0.91	0	0	0	0
FL Feb.	Hr	1.04	0.72	1.55	1.39	1.04	0.72	1.04	0.72
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
OC Dec.	Tshs	0	0.37	0	0.93	0	0.37	0	0.37

Model D:

Mechanization and Manual Technologies: Early-Planted Cotton, Maize, and Late-Planted Cotton for Nonparticipants

Late-planted cotton was included in the same way it was included for participating farmers. The results of the analysis are shown in Tables 6.27 and 6.28.

In Models D_1, D_3, and D_4, the area planted in early cotton declined from 1.25 in the bench-mark to 0.61 hectares, that planted in maize increased from 1.38 to 1.89 hectares, and that under late-planted cotton increased to 0.13 hectares. There was no change in total cultivated land. However, the use of labor and operating capital declined. Employment of family labor, hired labor, labor from working parties, and operating capital declined by 7.68 percent, 100 percent, 50.76 percent, and 16.89 percent respectively. Although the decline in the use of labor resulted from a decline in hectarage planted in early cotton, the decline in operating capital was caused by the decline in hired labor and working parties in addition to the decline in inputs such as fertilizers and insecticides that resulted from the reduction in cotton hectarage. The estimated net farm income came to Tshs 4135.89 compared to Tshs 4027.18, an increase of 2.69 percent. The returns to land, to unpaid labor, and to a unit of operating capital increased by 2.69 percent. The returns to land, to unpaid labor, and to a unit of operating capital increased by 2.69 percent, 10.41 percent, and 23.62 percent respectively.

Table 6.27

Comparison of Bench-Mark and Optimal Organizations Under Existing Resources and Offical Price for Early and Late Cotton, and Free-Market Price for Maize for Nonparticipants

ITEM	UNIT	BENCH-MARK	OPTIMAL ORGANIZATIONS							
			MODEL D_1	% CHANGE	MODEL D_2	% CHANGE	MODEL D_3	% CHANGE	MODEL D_4	% CHANGE
Net Farm Income (NFI)	Tshs	4027.18	4135.89	+ 2.69	4088.21	+ 1.54	4135.89	+ 2.69	4135.89	+ 2.69
Land (Early Cotton)	Ha	1.25	0.61	-51.20	0.73	-41.60	0.61	-51.20	0.61	-51.20
Land (Maize)	Ha	1.38	1.89	+36.95	1.82	+31.88	1.89	+36.95	1.89	+36.95
Land (Late Cotton)	Ha	0	0.13	+100	0.08	+100	0.13	+100	0.13	+100
Total Land	Ha	2.63	2.63	0	2.63	0	2.63	0	2.63	0
Family Labor	Hrs	4192.16	3870.12	- 7.68	3493.54	-16.66	3870.12	- 7.68	3870.12	- 7.68
Hired Labor	Hrs	68.00	0	-100	0	-100	0	-100	0	-100
Working Party	Hrs	114.70	56.47	-50.76	20.66	-81.98	56.47	-50.76	56.47	-50.76
Total Labor	Hrs	4374.86	3926.59	-10.24	3514.20	-19.66	3926.59	-10.24	3926.59	-10.24
Ox Team (Owned)	Ox Hrs	78.90	-	-	78.90	0	-	-	-	-
Ox Team (Hired)	Ox Hrs	26.75	-	-	-	-	0	0	-	-
Tractor (Hired)	Trc Hrs	4.80	-	-	-	-	-	-	0	0
Operating Capital	Tshs	856.35	711.64	-16.89	618.04	-27.83	711.64	-16.89	711.64	-16.89
NFI/Ha	Tshs	1531.24	1572.58	+ 2.69	1554.83	+ 1.54	1572.58	+ 2.69	1572.58	+ 2.69
NFI/Hr of Unpd Labor	Tshs	0.96	1.07	+10.41	1.17	+21.87	1.07	+10.41	1.07	+10.41
NFI/Operating Capital	Tshs	4.70	5.81	+23.62	6.62	+40.77	5.81	+23.62	5.81	+23.62

In Model D_2, the results were not much different from those in Models D_1, D_3, and D_4. The early-planted cotton hectarage decreased from 1.25 in the bench-mark to 0.73 hectares, the area under maize increased from 1.38 to 1.82 hectares, and the area under late-planted cotton came to 0.08 hectares. As a result of these changes in areas cultivated, the bench-makr employment family labor, hired labor, working parties, and operating capital declined by 16.66 percent, 100 percent, 81.98 percent, and 27.83 percent respectively.

The estimated net farm income rose from Tshs 4027.18 in the bench-mark to Tshs 4088.21, a slight increase of 1.54 percent. Consequently, the net farm income per hectare, the return to unpaid labor, and the return per unit of operating capital increased by 1.54 percent, 21.87 percent, and 40.77 percent respectively.

Marginal-Value Products (MVPs) of Resources Under Models D_1 to D_4

The MVPs of resources are presented in Table 6.28. Land became more constraining in all models. In Models D_1, D_3, and D_4, the MVPs of land increased from Tshs 465.22 in the base plan to Tshs 591.64 in the new plan. In Model D_2, the MVP of land under the new plan came to Tshs 658.13 compared to Tshs 514.67 in the base plan. As labor became less constraining, the MVP of land went up. The decline in the MVPs of family labor was evident in October (for Models D_1, D_3, and D_4), in November, in January (for Model D_2), and in February. In October, the MVP of family labor declined from Tshs 1.64 to Tshs 1.27. In November it declined from Tshs 1.81 to 1.56 for Models D_1, D_3, and D_4, and from Tshs 0.98 to 0.60 for Model D_2. In February, the MVP of

Table 6.28

Marginal-Value Products (MVPs in Tshs) of Resources for Models D_1 to D_4 for Nonparticipants

RESOURCE	UNIT	Model D_1		Model D_2		Model D_3		Model D_4	
		Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan	Base Plan	New Plan
Land	Ha	465.22	591.64	514.67	658.13	465.22	591.64	465.22	591.64
FL Oct.	Hr	1.64	1.27	0	0	1.64	1.27	1.64	1.27
FL Nov.	Hr	1.81	1.56	0.98	0.60	1.81	1.56	1.81	1.56
FL Jan.	Hr	0	0	1.06	0.74	0	0	0	0
FL Feb.	Hr	1.04	0.63	1.55	1.02	1.04	0.63	1.04	0.63
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06

family labor declined from 1.04 to 0.63 Tshs for Models D_1, D_3, and D_4, and from 1.55 to Tshs 1.02 for Model D_2.

The results for Models D_1 and D_4, as with those for Models B_1 to B_4, indicated some potential for reducing seasonal labor bottlenecks and increasing farm income. In contrast to Models B_1 to B_4, however, labor was not the only bottleneck. As the analysis showed, land was a major constraint among the nonparticipants. Labor- and land-saving technologies were more or less equally important issues to these farmers.

Comparison of Optimal Organizations with Existing Resources and Prices for Participants and Nonparticipants

In this section, the analyses of the results from the linear-programming models for the participants and nonparticipants are compared. The apparent assumption in this comparison is that participating farmers adopted, at least partially, the recommended crop practices such as the application of plant nutrients (organic and inorganic), spraying of insecticides, and three to four weedings, whereas the nonparticipating farmers did not. The assumption is based on the following: that participating farmers used more TSP, SA and insecticides per hectare; that they weeded their fields at least three times; that they were closely supervised by extension workers; and that they had more access to the recommended inputs.

A comparison of the optimal organizations of the two groups of farmers is presented in Table 6.29. Models A_1 to A_4 referred to the optimal organizations for the participants; Models C_1 to C_4 referred to the optimal organizations for the nonparticipants.

Table 6.29

Comparison of the Optimal Organizations of the Representative Farms for Participants and Nonparticipants with Existing Resources and the Official Price for Early Cotton and Free-Market Price for Maize

ITEM	UNIT	OPTIMAL ORGANIZATIONS											
		Model A_1[a]	Model C_1[b]	% Change	Model A_2[a]	Model C_2[b]	% Change	Model A_3[a]	Model C_3[b]	% Change	Model A_4[a]	Model C_4[b]	% Change
Net Farm Income (NFI)	Tshs	5538.46	4260.83	-23.06	5729.60	4211.49	-26.49	5614.93	4260.83	-24.11	5538.46	4260.83	-23.06
Land (Early Cotton)	Ha	1.65	1.12	-32.12	1.65	1.09	-33.94	1.65	1.12	-32.12	1.65	1.12	-32.12
Land (Maize)	Ha	1.30	1.51	+16.15	1.37	1.54	+12.41	1.32	1.51	+14.39	1.30	1.51	+16.15
Total Land	Ha	2.95	2.63	-10.84	3.02	2.63	-12.91	2.97	2.63	-11.45	2.95	2.63	-10.84
Family Labor	Hrs	3684.99	3778.23	+ 2.53	3761.99	3506.40	- 6.79	3695.16	3778.23	+ 2.25	3684.99	3778.23	+ 2.53
Hired Labor	Hrs	104.53	0	-100	104.53	0	-100	104.53	0	-100	104.53	0	-100
Working Party	Hrs	652.72	27.51	-95.79	718.06	12.67	-98.24	687.31	27.51	-95.99	652.72	27.51	-95.79
Total Labor	Hrs	4442.24	3805.74	-14.32	4584.58	3519.07	-23.24	4487.00	3805.74	-15.18	4442.24	3805.74	-14.32
Ox Team (Owned)	Ox Hrs	-	-	-	89.98	78.90	-12.31	-	-	-	-	-	-
Ox Team (Hired)	Ox Hrs	-	-	-	-	-	-	46.82	0	-100	-	-	-
Tractor (Hired)	Trc Hrs	-	-	-	-	-	-	-	-	-	0	0	0
Operating Capital	Tshs	1026.74	569.80	-44.50	1241.35	595.52	-52.03	1304.40	569.80	-56.32	1026.74	569.80	-44.50
NFI/Ha	Tshs	1877.44	1620.09	-13.71	1897.21	1601.32	-15.59	1890.55	1620.09	-14.30	1877.44	1620.09	-13.71
NFI/Hr of Unpaid Labor	Tshs	1.50	1.27	-15.33	1.52	1.20	-21.05	1.51	1.27	-15.89	1.50	1.27	-15.33
NFI/Operating Capital	Tshs	5.39	9.07	+68.27	4.62	7.07	+53.03	4.30	9.07	+110.93	5.39	9.07	+68.27

[a]Models of the Participants

[b]Models of the Nonparticipants

The optimum organization for farmers using only manual technologies showed that the area planted in early cotton was 32.12 percent greater for the participants (Model A_1) than for the nonparticipants (Model C_1). However, the area planted in maize in Model C_1 was larger by 16.15 percent. The optimal use of family labor was 2.53 percent higher for Model C_1 than for Model A_1; in the latter model labor was not only hired but some was obtained through working parties. Such a use of labor reflected the difference in the optimal cropping pattern presented above. In addition, much more operating capital was used in Model A_1.

The net farm income in Model A_1 was 23.06 percent higher than in Model C_1. Consequently, the net farm income per hectare and return to unpaid labor were also higher by 13.71 percent and 15.33 percent respectively. Only the returns to a unit of operating capital was higher for Model C_1. The difference in net farm income was not only a result of differences in cropped area but also of differences in yields per hectare. By comparing measures of efficiency, i.e., net farm income per hectare, return to unpaid labor and to a unit of operating capital, the optimum farm organization of the representative farm for the participants was to a larger extent, more efficient. The same conclusion was reached when a comparison was made between Models A_2 and C_2, A_3 and C_3, and A_4 and C_4.

The MVPs of resources for the two grups of farmers are shown in Table 6.30. The MVPs of land for the participants (Models A_1 to A_4) was zero; those for the nonparticipants (Models C_1 to C_4) were positive. This indicated that land was a limiting factor among the nonparticipating farmers.

Table 6.30

Comparison of Marginal-Value Products (MVPs in Tshs) of Resources Between Participants and Nonparticipants with Existing Resources and the Offical Price for Early Cotton and Free Market Price for Maize

RESOURCE	UNIT	MODEL A_1	MODEL C_1	MODEL A_2	MODEL C_2	MODEL A_3	MODEL C_3	MODEL A_4	MODEL C_4
Land	Ha	0	465.22	0	514.67	0	465.22	0	465.22
FL Oct.	Hr	2.99	1.64	0	0	0	1.64	2.99	1.64
FL Nov.	Hr	2.75	1.81	2.87	0.98	2.59	1.81	2.75	1.81
FL Dec.	Hr	1.08	0	1.60	0	1.40	0	1.08	0
FL Jan.	Hr	0.93	0	1.28	1.60	1.19	0	0.93	0
FL Feb.	Hr	1.12	1.04	2.03	1.55	2.21	1.04	1.12	1.04
FL May	Hr	0.95	0	1.16	0	1.76	0	0.95	0
TSP	Kg	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
SA	Kg	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
THDN	Tshs	13.34	13.34	13.34	13.34	13.34	13.34	13.34	13.34
DDT	Tshs	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06
OC Oct.	Tshs	0.49	0	0.81	0	0.98	0	0.49	0
OC Nov.	Tshs	0.49	0	0.20	0	0.07	0	0.49	0
WP LMT Oct.	Hr	1.37	0	0	0	0	0	1.37	0
WP LMT Nov.	Hr	1.66	0	1.79	0	1.52	0	1.66	0

In general, family labor was more restricting for the participants. The MVPs of family labor were positive in the months of October (except for Model A_2), November, December, January, February, and May compared to October (except for Model C_2), November, January (for Model C_2) and February for the nonparticipants. There were two explanations for this difference. One was that the participating farmers employed more labor because they cultivated more land than the nonparticipants did. Another was that participating farmers used more labor per hectare during weeding because they followed the recommended practice of weeding.

Another main difference in the use of resources was shown by the MVPs of operating capital. For the participants, operating capital was a constraint in October and November; for the nonparticipants, operating capital was not a constraint in any month. This did not mean that the latter group of farmers had more operating capital than the participants. Rather participating farmers spent more cash on buying fertilizer and insecticides and paying for labor.

Summary

The results of the study indicated that both groups of family farms had potential for achieving increases in farm incomes, resource use, and productivity irrespective of which mechanical technologies they used. Among the participating farmers, however, Model A_2 (the employment of labor and owned ox teams) was slightly more profitable than Models A_1, A_3, or A_4. Because of labor bottlenecks during land preparation, the owned ox team in Model A_2 helped expand the area planted in maize. Model A_3 (use of labor with hired ox teams) was the next most profitable farm practice. But the shortage of operating capital limited its application. Hired tractors were considered to be unprofitable.

For the nonparticipants, manual technologies were the most profitable. With an average of 2.63 hectares, neither owned ox teams, hired ox teams, nor hired tractors were profitable. Thus, those farmers who owned ox teams would have been better off if they had employed labor for all farming operations. The same conclusion applied to those who hired ox teams. For owners of ox teams, there was an advantage of receiving income from custom work. This income, however, was subtracted from the farmers' net incomes.

For both groups, the variations in relative product prices produced substantial changes in cropping patterns. Under Alternative Ia, the area planted in maize was drastically reduced for both groups; the area planted in cotton, on the other hand, increased tremendously. Under Alternative Ib, the increase in cotton price further reduced the area planted in maize and increased that planted in cotton. Under Alternative Ic, the area planted in each crop was not far from the area in the bench-mark. The latter alternative also provided the best results in terms of net farm income and return to land, labor, and to a unit of operating capital.

The impact of changing relative product prices for cotton and maize on maize production by participants and nonparticipants is illustrated in figures 6.1 and 6.2 respectively. As the ratio of the price of cotton to maize is increased, the percentage of land planted to maize decreases. At point a, land planted to maize is 44.4 percent for participants and 5718 percent for nonparticipants. If the price of cotton is increased by 25 percent (point b), land planted to maize declines to 42.7 percent and 52.5 percent for participants and non-participants respectively. This is a slight change compared to the change between Alternatives Ic and Ia (points b and c) in which land planted to maize drops from 42.7 percent and 52.5 percent to 20.9 percent and 20.1 percent respectively. In this case, a 1 percent increase in cotton price while keeping that for maize constant leads to a more than 1 percent decline in land planted to maize. Apparently, the production of maize is very sensitive to price changes. This extreme sensitivity to price changes has two main effects. First, it creates wide variability in the quantity of maize marketed because farmers will satisfy family maize consumption needs before they sell. Undoubtedly, the government's objective of food self-sufficiency wil be undermined. Second, farmers' net farm income would be destabilized as a result of more land planted to cotton. As mentioned in Chapter III and in the early part of this chapter, farmers in the area experience year-to-year higher variability in cotton than in maize yields. Thus, any increase in land planted to cotton at the expense of maize leads to high variability in farmers' net earnings. As a result, farmers' ability to purchase farm inputs such as labor, fertilizers and insecticides, and consumer goods such as other food items not produced on the farm, is also destabilized.

From Alternatives Ia to Ib (point c to d) area planted to maize drops from 20.9 percent to 19.2 percent and from 20.1 percent to 18.3 percent for nonparticipants. A similar slight change in land planted to maize is seen between Alternative Ib (point d) and point e (when official prices for cotton and maize are employed). Between point c and c, area planted to maize is generally stable. The ratio of cotton to maize prices is too high to induce farmers to produce maize for both household consumption and for sale. Instead, they decide to product only for household consumption. With more land devoted to cotton production the wide variability of farmers' earnings is also experienced between point c and e.

It is quite evident from Figures 6.1 and 6.2 that in terms of meeting the government's objectives of (1) food self-sufficiency; (2) increasing cotton output for export and domestic use, and (3) improving the standard of life for the rural population through increased and stable incomes, the range between points a and b provide the best guidance to price policy issues.

The impact of increased fertilizer and insecticide prices on net farm income, cropping patterns, and resource use was also more or less the same for both groups. Net farm incomes were reduced in both groups and for all models. Although there was a reduction in the area planted in cotton and maize for the participants, the area planted in maize was increased at the expense of the cotton area for the nonparticipants. Maize demanded less inputs (TSP, SA, DDT) per hectare than did cotton for the latter group.

An increase in the October and November operating capital for participants decreased cotton hectarage and increased the area planted in maize in each model. This change, however, led to an increase in net farm income.

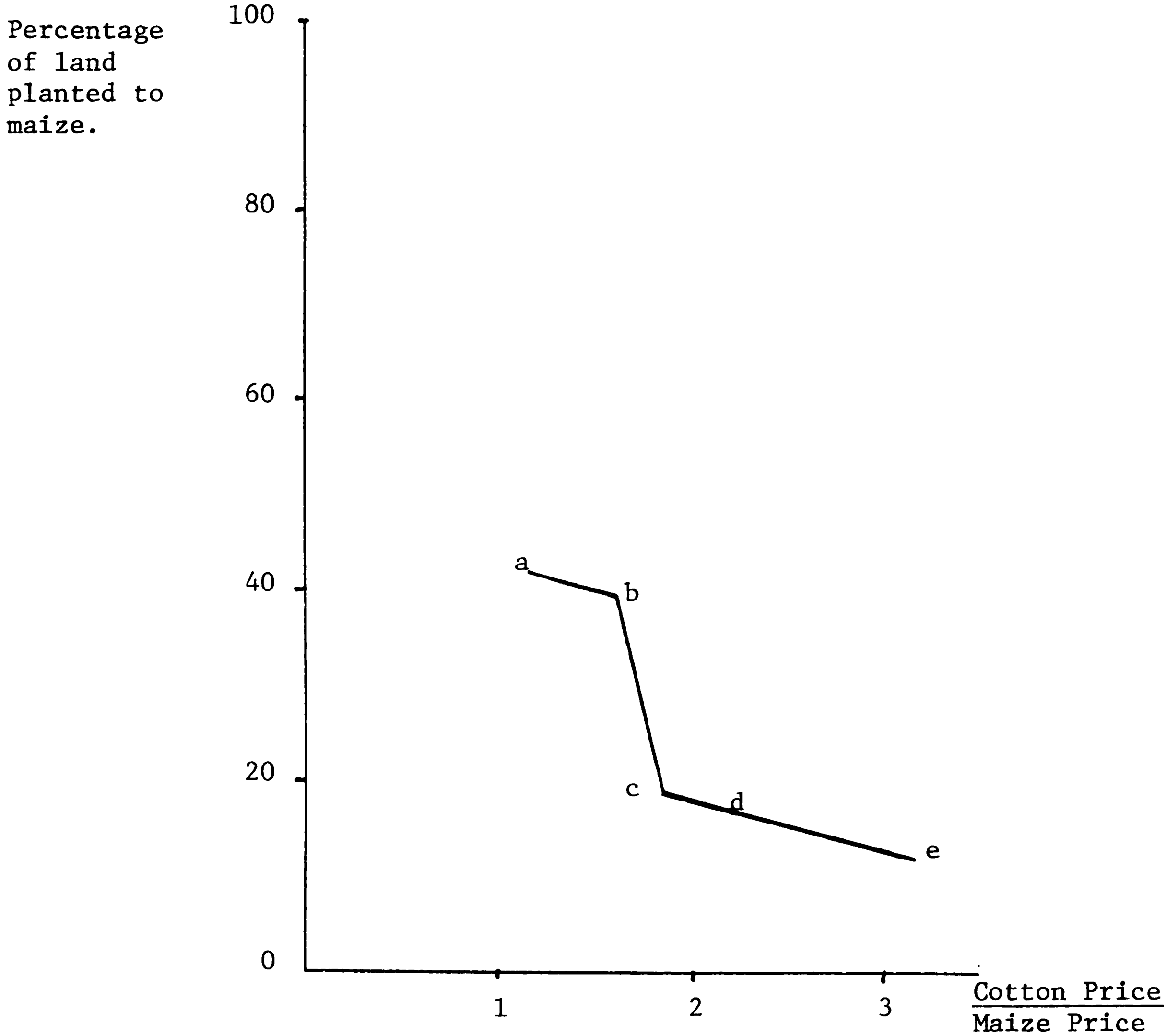

FIGURE 6.1 The Impact of Relative Product Prices on Maize Production for Participants

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[a]Free market price for maize and official price for cotton.

[b]Alternative Ic

[c]Alternative Ia

[d]Alternative Ib

[e]Official prices for cotton and maize.

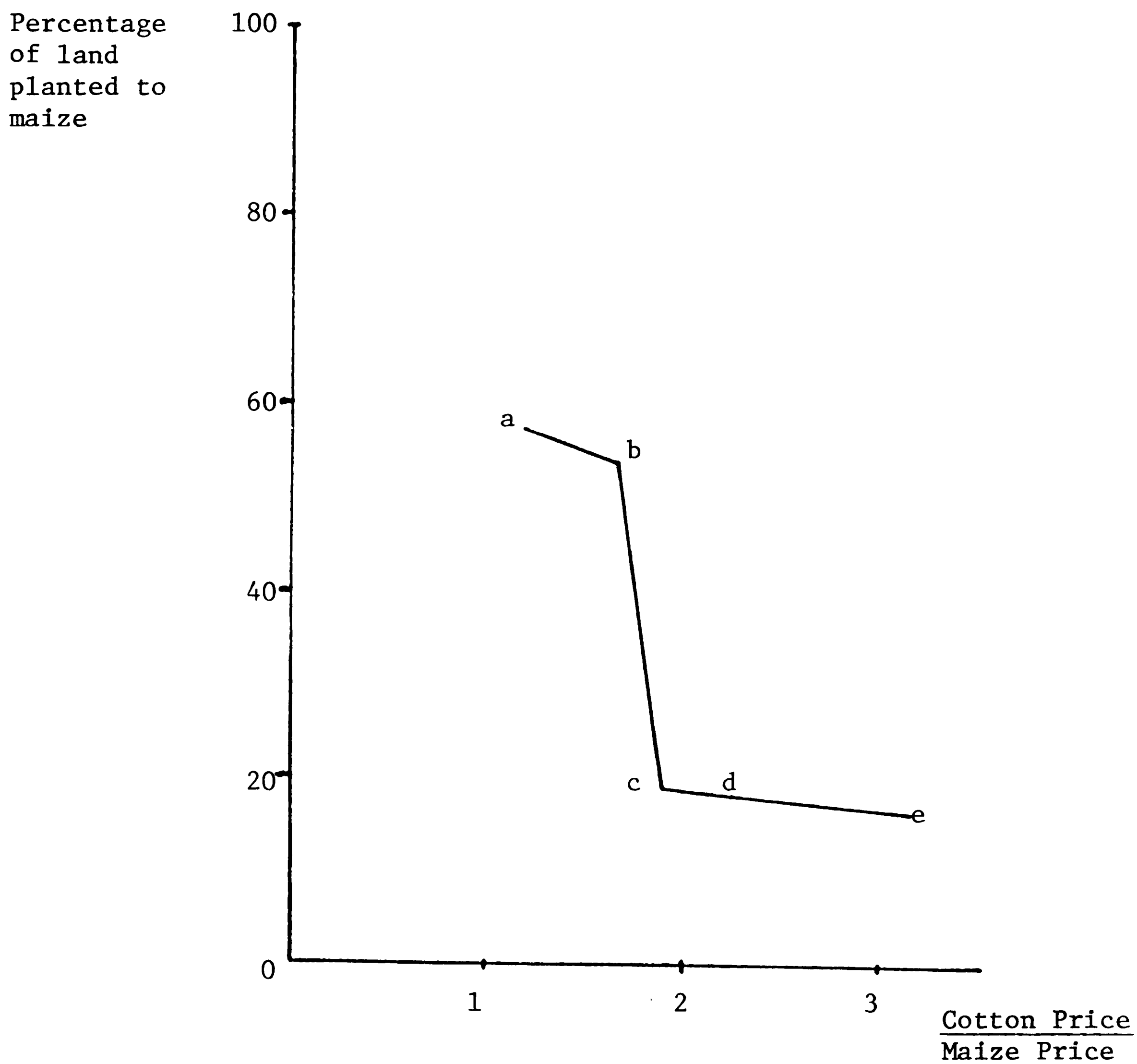

FIGURE 6.2 The Impact of Relative Product Prices on Maize Production for Nonparticipants

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[a]Free market price for maize and official price for cotton.

[b]Alternative Ic

[c]Alternative Ia

[d]Alternative Ib

[e]Official prices for cotton and maize.

The impact of spacing out farm operations between maize and cotton on net farm income, cropping patterns, resource use, and productivity was also analyzed. This was done as a way of alleviating labor bottlenecks that were so apparent in the optimal solutions. For participating farmers, both maize and cotton output would increase as a result of an increase in the area planted in both crops and despite a 20 percent decline in cotton yield per hectare associated with late-planted cotton. Higher yields per hectare for cotton could be increased if research at Ukiliguru could produce a drought-resistant cottonseed.

The results for nonparticipants, however, were rather different. Maize output would increase tremendously due to a substantial increase in maize hectarage; cotton would decline because the area decreased and an hectare of late-planted cotton would produce 20 percent less than an hectare of early-planted cotton. Land shortage was also a factor here. Under existing resources and prices, one crop could be expanded only at the expense of the other.

Net farm income would increase for the participants as a result of changes described above. Increased cropping area for the participants would offset any possible minimization of labor bottlenecks; notable changes would be in March and April, when family labor would be scarce. Labor bottlenecks would occur during the same months as those under the base plans for the nonparticipants. If late-planted cotton were included, the scarcity of labor could be minimized.

CHAPTER VII

SUMMARY, POLICY ISSUES, LIMITATIONS OF THE STUDY, AND SUGGESTIONS FOR FURTHER RESEARCH

Summary

The general objective of this study is to analyze empirically the impact of the government's measures to increase agricultural output on farm income, cropping patterns (including output), and resource productivity on small-holder family farms in Geita district of Tanzania. Specifically, the objectives of the study were (1) to evaluate the impact of the constraints imposed by farm resources on the production of cotton and maize; (2) to assess the implications of oxen and tractor technological choices with respect to their impact on net return per hectare, on employment, and on labor productivity; (3) to analyze the impact of rescheduling agricultural production (by including early- and late-planted cotton) on resource allocation, agricultural output, and farm earning; and (4) to test the sensitivity of alternative input and output prices on resource allocation, enterprise combinations and net farm income.

Cotton and maize production is influenced by the overall national and locational problems facing the Tanzanian agricultural sector. The national problems range from poor marketing and pricing policies to insufficient research studies, insufficient roads, lack of road maintenance, insufficient low-cost transportation facilities, unclear bureaucratic structure, poor training, and lack of trained planners. The locational problems of increasing agricultural output and agricultural productivity include land scarcity, drought conditions, and labor shortages.

Solutions to such problems require specific studies as a basis for formulating specific policies. So far, little attention has been paid to these areal problems and solutions.

Instead, different measures have been taken in response to the falling agricultural output. The following few examples reflect some of the alternatives attempted. First, since 1974, a single pan-territorial producer price for each crop has been fixed annually by the economic committee of the cabinet. Differentials in the uniform price are fixed for different quality grades where applicable, but no distinction is made with respect to location or transport costs. Second, each year the Revolutionary Party (the only political party in the country) directs regions to meet crop targets set by the national party leaders. These targets are often arbitrary and are not accompanied by any incentive for being met or punishment for not being met. Third, in 1975 an agreement was made between the Tanzanian government and the World Bank in which the latter would provide funds (on a loan basis) for improving agricultural practices in the major cotton- and tobacco-growing areas. The main purpose of this agreement was to introduce biological innovations that involve the use of improved seeds, pesticides, and fertilizers, both organic and inorganic.

The production of cotton and maize in Tanzania is a complex process. These two crops play a very important role in the Tanzanian economy. Cotton accounts for more than 17 percent of Tanzania's total exports which in turn make up for about 30 percent of the country's GDP. The crop is a source of foreign exchange that the country needs badly to pay for imports. In addition, more cotton is needed each year to meet its demand by expanding domestic textile industry. Maize, on the other hand, is the staple food in Tanzania. If the country cannot produce enough maize to meet domestic demand, the government has to spend some of its scarce foreign exchange to import it. Unfortunately, domestic demand for maize has often exceeded domestic supply.

The measures taken to increase the production of such important crops as cotton and maize have not been based on an understanding of the complex interactions between resource allocation and risk minimization that frequently influence the adoption of new innovations among small-holder family farms. Such complex interactions become more evident in areas in which main food crops compete with main export crops for the resources available to the family-farm households. Information on the utilization of land, labor, and implements in particular environmental and cultural practices is needed by policy makers. Unfortunately, such information is hardly available. In most studies (examples given in Chapter II) on agricultural production in small-farm economies little effort is made to analyze more than one crop. This is especially true in situations where crops are competitive with each other. Often the whole problem is seen from the macro point of view and is studied by using secondary and aggregated data. It was urged that any policy that is intended to achieve national targets in agricultural output and productivity must address itself to understanding the behavioral characteristics of farmers.

Geita district, in Mwanza region of Tanzania was chosen as the area for the study because it is the most important cotton producing area and one of the main areas for maize production in Tanzania. In Geita district, cotton and maize compete for farm resources, especially labor during land preparation, planting, weeding, and harvesting.

The Geita district, is an area which receives enough rainfall for cotton, maize, and other food crops such as cassava, legumes and vegetables. Most of the soils are also suitable for these crops. The district is estimated to have 909,000 hectares of cultivable land. About half a million people live in the district, with an average household size of 7.1 persons. Cotton is the main cash crop while maize is produced both for household consumption and for sale. Production of maize for consumption is given first priority by farmers. All farmers surveyed practice ridge cultivation which is regarded as beneficial to crop growth and erosion control. However, it is a practice that requires a lot of labor to operate.

Generally, the farming season begins in August with land clearance and ends in June with harvesting and sorting of cotton into clean and dirty piles. Most cotton and maize is grown in block farms. Farmers included in the Geita Cotton World Bank project (participants) practice improved farming by following recommended practices such as employing a good weeding program, use of fertilizers, and spraying crops with insecticides. Nonparticipant farmers seldom follow such practices.

The research methodology used in this study for both the participants and nonparticipants in the Geita Cotton area was static linear programming and parametric linear programming. These techniques were used to determine the organization that would maximize net farm income under existing resources, prices, and technology; varying relative products, and input prices, as well as varying levels of operating capital when it was necessary. Linear programming was used in the study because (1) a large number of interrelated variables can be handled, and thus family-farm systems that are characterized by a high degree of interdependence between production and consumption, consumption and investment, investment and resource availability, and social and cultural constraints; (2) the maximum possible profit for a farm-planning problem is guaranteed; and (3) it is easy to vary available prices and resources as well as input coefficients.

The sample in the study consisted of 80 farmers, 40 from participants and 40 from nonparticipants. This stratification was justified by the objectives of this study. For each group, a two-stage sampling method was employed. The first was to select villages in such a way that the final sample included farmers who used either manual, oxen or tractor technologies. The second stage dealt with the selection of farm households; this was done randomly from four prepared lists: households that had decided to employ labor only; households that owned plows; those who intended to hire plows; and the last list contained households that intended to hire tractor services. The needed data on production, prices, and resources availability and uses were collected through questionnaires. Data for only one cropping season, 1979-80 were collected by six well trained enumerators. In order to estimate optimum plans, data from the farms were averaged and assumed to form a representative farm for that group.

The structure of the linear-programming model is tailored to fit the unique aspects of the study. The objective function to be maximized was net farm income subject to meeting the minimum maize-consumption requirements of the farm household. The construction of linear programming models included crop-production activites, labor-hiring activities, working party activities, animal-power owning activities, animal-power hiring activities, tractor-hiring activities, fertilizer- and insecticide-buying activities, crop-consumption activity, crop-selling activities, animal-power selling activities, and transfer activities. The last group of activities was included to transfer surplus operating capital from one month to another.

The results obtained from the linear programming analysis led to the following conclusions. First, there is a need to remove labor bottlenecks if production is to be increased. These bottlenecks can be removed in four ways: (1) by increasing the intensity of the family-labor inputs; (2) by hiring additional labor if it is available in the area for the peak periods at the going wage rate or by organizing working parties; (3) by mechanizing through switching to animal draft power or tractor cultivation; or (4) by changing the cropping calendar so that seasonally required labor resources do not exceed seasonally available labor resources.

Farmers will increase the intensity of the family labor input only when it is economically beneficial to them. Input-output pricing policies and their intended purpose must be quite beneficial before farm households intensify the use of family labor. Hiring of additional labor is constrained by two factors. First, it is politically discouraged by the government's policy of building a socialist society in which no individual would work for another individual for money. Second, as a result of the above factor, there is no guarantee that such a type of labor would be available in the future. If this type of labor remains available, the difference between demand and supply for hired labor will increase the wage rate. Thus, more operating capital will be demanded. Working parties seem to be a better alternative as a source of labor; however, since most of this labor comes from other farm households, there is no assurance of getting it since other farm households are often also experiencing labor bottlenecks. Exchange labor would have been the best alternative and it is encouraged by the government. However, the limiting factor is farmers' suspicion of this system since it is always referred to as a step towards communal (socialist) farming.

The third possible way of removing labor bottlenecks is through mechanization, either by switching to animal draft power or tractor cultivation. The analysis has shown that under optimal organization, tractor power is not profitable; thus, it should not be used. It should be remembered that the use of tractors in the study area is confined to land cultivation. Although this reduces the labor requirement per hectare for this farm operation, it does not remove labor bottlenecks during other operations. This is not the only problem. Tractors are not manufactured in the country. To import them, the government has to spend its meager foreign exchange reserves. It is also worthwhile to note here that, whereas a tractor would not only require increased amounts of foreign exchange for purchasing fuel to run it, the price of oil on the world market has increased tremendously over the last eight years, and signs are that it will continue to spiral. The cost of hiring tractors would then be too high for small farmers to afford unless the government subsidizes them. For these reasons the government has correctly discouraged small farmers from using tractors. Instead, emphasis has been put on using ox plows.

There are four potential benefits attributed to using animal draft power. First, it allows the expansion of hectarage by reducing labor time required per hectare. Second, it leads to higher yields, which result in the short run from better and more timely performance due to the use of manure and crop residues. Third, labor time saved may be devoted to other activities of value to the farm household. Fourth, crop removal and marketing can be facilitated by the use of animal drawn carts and can thus provide a source of income from custom transport where the demand for that service exists.

The results obtained from the analysis, however, indicate that the economic benefits of animal draft power not only depend on the extent of adoption but also on the intensity of its use. There are critical labor bottlenecks during ridging, weeding, and harvesting for most farmers. Given this situation, there is a need to adopt animal draft power for those operations. This type of power is particularly important for the participants, who face more serious labor bottlenecks during those operations; it should also be introduced to the nonparticipants as larger areas of land become available for cultivation.

In order to fully adopt the use of animal draft power, the government, through extension agencies, must train household farmers about how to use animal-drawn implements for the various farm operations, as well as the intensification of land use and maintenance of soil fertility. Not only that, but a credit system must be available so that farmers can borrow enough funds to purchase the required animal-drawn implements. The present institutions for inputs supply, repair and maintenance, animal health services, extension services, and marketing must be improved in order to meet the new demands for these inputs.

The early experiments with mechanization called for too many changes too quickly. This led to high costs, poor management of machinery, decline in soil fertility, and the variability in yields. Based on these bad experiences, farmers should be encouraged to adopt new technology, including the introduction of animal power, through a gradual process. For example, they should not be asked to undertake animal weeding until they have the trained animals and have learned how to weed without damaging crops. Step-by-step adoption of the technology may allow the farmer to move to higher technology farming methods and also keep his debt-service obligations within his ability to pay.

Equally important is the need to conduct research on the biological and mechanical aspects of animal-drawn equipment so that it can be adapted to diverse local conditions. Designs for plowing and weeding equipment should be developed for the different agronomic conditions found in different regions and districts.

Labor bottlenecks can also be removed if the cropping calendar is changed. Instead of maize and cotton competing for labor during the plowing, weeding, and harvesting operations, cotton could be planted later. The results indicated that this farming system is possible. For the average participating farmer, maize output could increase by about 9.94 percent while cotton could decline by 27 percent due to the 20 percent decrease in yield per hectare that resulted from late-planted cotton. Net farm income, however, could increase by about 10.2 percent. For an average nonparticipating farmer, cotton output could decrease by as much as 37.2 percent due to a reduction in the area planted in the crop as well as a 20 percent decline in yield per hectare. Maize output could increase by 34.99 percent as a result of a 35 percent increase in cropping area. The change in farm income could increase by 2.4 percent. Unlike an average participating farmer, a representative nonparticipating farmer is already facing land constraints. Thus, it is impossible to increase the area of one crop without decreasing that of the other. By changing the cropping calendar, maize seems to be more profitable to these farmers than cotton.

The adoption of this new farming system, however, is quite risky. It depends on the weather, particularly rain. If the rainy season is short, i.e. it ends in late February, late-planted cotton may not survive, and thus cotton output might fall drastically.

Another major finding of this study was that the official price of maize is significantly below the free-market price. Therefore, farmers are more likely to sell outside the officially approved marketing channels, in order to increase the profitability of the farm.

This research project also addressed the issue of input subsidies. If these are removed, the improved farming practices currently being followed by participants provide larger declines in gross margins than the unimproved practices currently being followed by the nonparticipants, whether output of maize is valued at the official (lower) price or at the free-market (higher) price. This suggests very clearly the role of input subsidies as presently used in the system. Improved practices provide higher gross margins over unimproved practices and hence an incentive to adopt them but only when modern inputs are highly subsidized. Thus, following improved practices tends to increase the level of physical output per hectare because the relative cost and

return relationship has been altered by the subsidy program. This is a direct income transfer to the farm sector that is being paid by other sectors in the economic system.

Thus, the present policies that subsidized modern inputs, coupled with the control of official market channels (output prices are fixed below the free-market price) offset each other to a large extent. The subsidized inputs are considered incentives to adopt new practices. From the farmer's viewpoint, what the government gives in input subsidies, it takes away in lower fixed prices. In addition, there is the added burden of administering and policing both input and output markets, a burden that has to be born by other sectors of the economy.

Policy Issues

On the assumption that the data, the analytical framework, and the unit of analysis all have a reasonable degree of validity, the quantitative results obtained from the study could provide relevant insights and guidelines that would aid policy makers and agricultural researchers. Some policy implications of the results obtained are presented here.

In the linear programming analysis, it was shown that small-holder family farms from both groups experience labor constraints during land tilling and ridging, weeding, and harvesting. The present use of tractors or ox plows does not solve seasonal labor bottlenecks because their use is confined to land tilling. Labor bottlenecks were mentioned by farmers in the area as one of the major limiting factors in increasing agricultural output. It follows, therefore, that any policy aimed at increasing agricultural output through expanding crop hectarage or even through intensification must be supported by labor-saving techniques. There may be a need to introduce new crops or crop mixtures that can increase productivity through flexibility in the timing of farm operations. There is also the possibility of complementing ox plows with a wide scope of low-cost implements such as ox-drawn multicultivators and seeders. Demand for such relatively simple farm implements can be substantial, especially when the introduction of such implements is accompanied by other yield-increasing technologies.

The potential demand for such implements needs to be supported by growth in the small-industry and service sectors of the rural or national economy. The promotion of draft equipment is, however, limited by its cost, which, though lower than motorized equipment on a per unit basis, still represents a considerable investment for small farmers. This calls for a formulation of credit policy based on the productivity of capital. This policy will place additional demand upon the Tanzania Rural Development Bank, and regional and district cooperatives as the source of short-term credit to farmers. Farmer-owned cooperatives may be more important in filling this role because they can more easily involve a large number of small-holder farms. Also, they may be in a better position to collect on the repayment of the loans. The success of such a policy, however, will also depend on yield-increasing technologies and higher ouput prices.

The results of the study also indicated that farm income, output, resource use and productivity are influenced by product prices and input prices to a much greater extent than they are by operating capital.

However, if the government removes the subsidies on inputs without increasing product prices and also not provide a source of credit to meet the high inputs costs, then operating capital is going to be a limiting factor. This emphasizes the complementarity of credit services and new techniques and suggests that credit should be made an important component of any new technology package.

Another policy issue that needs a careful and immediate review by the government is the producer price in particular and the marketing system in general. The present price policies have proved self-defeating. Lower and controlled prices for food crops have not succeeded in securing adequate supply of food stuffs. It also has increased farmers' risks in marketing food surpluses outside the official market. As a result, over time it has destabilized food supplies. Further, the present single national producer price for each crop, which is intended to insure that small farmers in remote areas are not disadvantaged on the grounds of location, involves costs that have to be recognized and taken into account when the trade-off between income and resource-allocation objectives is examined. Often these producer prices give wrong signs to farmers. Thus, in areas where maize cannot grow well because of weather conditions, a higher price of maize, compared to other food crops, tends to influence farmers in such areas in allocating more resources to maize than to other food crops. In areas like Geita, where maize and cotton are favored by weather, relative prices of these crops play a very important role in influencing farmers' decision-making processes.

Currently, the price for maize is too low compared to what farmers can get in the black market. Given the importance of such areas in producing both export crops and food crops, it may be necessary to replace the single pan-territorial pricing system with a locational pricing policy that could influence farmers indifferent areas of the country to make use of their comparative advantages. This change may have to be accompanied by a change in the present price-controlled system: the more crops that are brought into the price-control system, the more difficult it becomes to get their relative prices correct. It would be much easier to arrive at correct relative prices if prices of minor crops such as legumes, cassave, and potatoes could be determined by local markets.

The use of fertilizers and insecticides appears to have some positive impact on yields. The comparison in yields per hectare between the participants and nonparticipants is an indication of that impact since the participant farmers used more of the chemical nutrients than the nonparticipants. However, nonavailability, limited availability, and late arrival of these inputs caused many farmers to limit their use of these resources. Often it is the poor road system and lack of transport to bring the inputs to the farmers that cause those problems. Investment in all weather feeder roads will enable fertilizer to be delivered in the rural areas even during the rainy season when some of these roads are now impassable. In addition, a credit system should be available to local cooperatives to construct permanent storage facilities. The proximity of available inputs will reduce the already substantial transport costs. Investments in such infrstructures will definitely have high payoff in the long run.

It is important to stress here that the policy suggestions made here are not mutually exclusive. They need to be discussed and reviewed as complementary since their simultaneous application will result in greater impact.

Limitations of the Study and Suggestions for Further Research

The scope of the application of the results of the study is limited by the reliance on one year's data and by the fact that the consequences of variations in input-output coefficients were not analyzed. Thus, the results of the study need to be complemented with the results of similar studies and personal experiences from other areas and for different years in order to obtain a comprehensive picture that may help policy makers.

Further, linear programming estimates are limited in that they are generated in the context of assumptions and model specifications underlying the linear model. The closer these assumptions and model specifications approach an accurate reflection of the decision environment for small-family farms in the study area, the more valid the results are likely to be. In the study, it was assumed that small-family farmers in the study area had as their objective maximization of net farm income subject to meeting minimum food requirements. However, farmers are more dynamic, and this assumption may not hold. To the extent that the assumption fails, farmers' actual decisions may differ significantly from those indicated as optimum by the results of this study.

Apparently, the approach adopted in this study provides only partial-equilibrium solutions. It is most unlikely that in the long run the price of maize for instance, can go up if that for cotton remains constant. Further the exclusion of other food crops such as cassavas and legumes has obviously affected the results obtained in this study; this is particularly so since the price for maize was determined in a free (black) market for food crops.

In addition, the lack of risk and uncertainty considerations is another characteristic of the static economic assumption under which the linear programming models were constructed. However, small family farmers will be faced by uncertainties regarding changing economic and political institutional elements, technologies and so on in the decision-making context. The results might be quite different from those obtained in this study.

A comprehensive national policy on agricultural production cannot be based on such isolated studies. There is a need for similar research in other areas of the country where similar problems are found. The most well-known example is Tabora region where tobacco competes with maize for resources.

There is also a need for research on the impact of input subsidies vis-a-vis higher product prices. Currently, there are no empirical studies on these issues that can help policy makers who often have to choose between input subsidies and product-price supports.

During the last decade, Tanzania has spent quite a substantial amount of scarce resources on input subsidies without adequate knowledge of the payoffs or the distributive effects. Given the government's concern with equity considerations, research is required on the impact of past expenditures on agricultural output and their income-distribution effects.

Research is also needed to determine the impact of high levels of fertilization on agricultural output, farm income, and the acidity of the soils. This need arises because of the unknown impact of fertilization. Similar research is needed to show the impact of insecticides on output and farm income. These studies should be as locationally specific as costs and manpower constraints can allow.

The absence of detailed recommendations on agricultural practices for maize (see Chapter III) call for more research on cultivation practices, input uses, and so on. Such research may provide valuable information that can be used in resources allocation decisions.

Further, much research has to be done in an attempt to develop cotton seeds that may endure a relatively dry or short rainy season. This might turn out to be very costly, and it will take a long time before farmers fully adopt it. Yet it is a possibility that should be explored along with the others that are discussed above.

The long-term solution to the labor problem that was discussed in this study requires comprehensive research on mechanization, especially on animal-drawn equipment. The research should cover the issues of the adaptability of the technology to diverse local conditions; the required supportive services, such as extension services, supply of inputs, credit, repair, and maintenance; the impact on desired cropping patterns, production, resource use, and their financial returns; and, above all the nature of interaction between mechanical technology and labor bottlenecks on the one hand, and between mechanical technology and biological innovations on the other

APPENDICES

APPENDIX A

THE STRUCTURE OF GDP (FACTOR COST) IN 1966 PRICES

	1965-67	1971-73	1973-75
Agriculture	44.5	39.7	38.1
Mining and Quarrying	2.8	1.2	0.7
Manufacturing	8.1	10.0	9.9
Trade	12.3	12.1	12.0
Transport	7.4	10.1	10.3
Finance	10.2	9.9	9.9
Public Administration	10.9	12.6	14.6
Other Services	3.8	4.4	4.5
Total	100.0	100.0	100.0

APPENDIX B

NUMBER OF TRACTORS AND OX PLOWS IN GEITA DISTRICT

YEAR	TRACTORS[a]	OX PLOWS
1978	24	290
1979	1	333
TOTAL	25	623

Source: Geita District Annual Report, 1979 (Unpublished).

[a]As owned by the Geita Cotton Project.

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